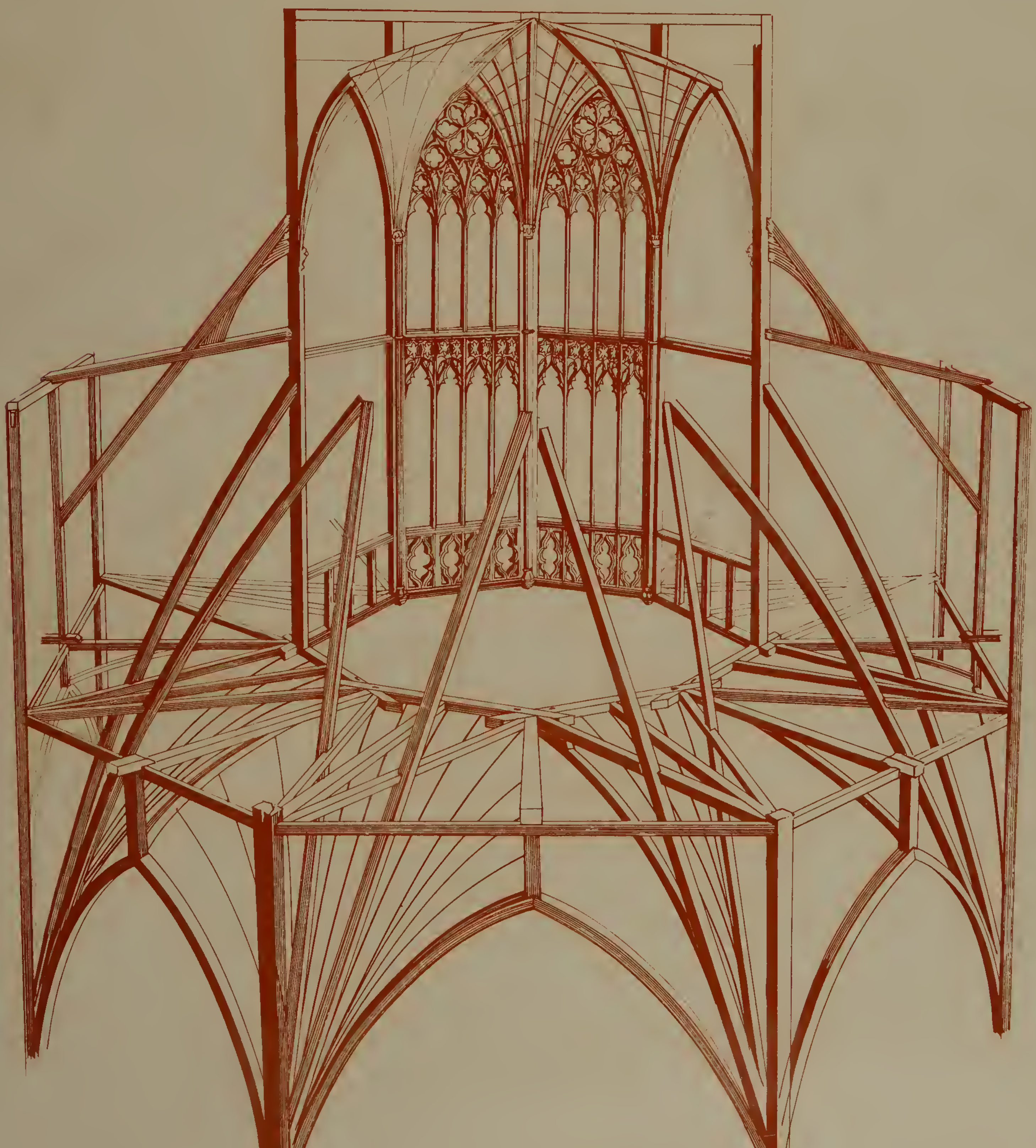
ENGLISH CATHEDRAL CARPENTRY

CECIL HEWETT



FOREWORD BY JOHN HARVEY

The cathedrals embody the finest craftwork of English medieval architecture. Collectively they stand as our most important architectural monuments. This importance has long been reflected in a great mass of specialist literature, yet in at least one major field research has not been merely inadequate but almost non-existent. This is the field of functional carpentry and in this book Cecil Hewett shows how major a part was played by the carpenter in the complex process of cathedral-building.

Illustrating his text with more than 160 magnificent line drawings, Mr. Hewett describes the carpenters' work that still survives in English cathedrals. He devotes chapters to ridged main-span roofs, lean-to roofs, apse roofs, polygonal chapter house roofs, doors and the few surviving windlasses and capstans that hoisted materials during building. Each chapter contains an outline of the broad course of development, the examples being placed in chronological order. In the appendix the author lists the carpentered contents of each cathedral and includes in the specialist glossary definitions of timber joints referred to in the text.

As John Harvey writes in his foreword; "At the cost of a great deal of very hard work and much discomfort Mr. Hewett here places on record a definitive and irreplaceable study."

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ENGLISH CATHEDRAL CARPENTRY

C. A. HEWETT

Foreword by John Harvey

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By the same author

The Development of Carpentry, 1200–1700: an Essex study
Church Carpentry, based upon Essex examples

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FOREWORD

The architecture of English cathedrals began to excite the interest of travellers as far back as the fourteenth century; serious historical study has been in progress for nearly two hundred years. It might be thought that very little was left to learn from the fabrics and the written records. It has been realised quite recently that this is not the case. In at least one most important field research has been not merely inadequate but almost non-existent: the functional carpentry. This is mainly, although not exclusively, that of the roofs, normally hidden above stone vaults and only accessible with difficulty, in darkness and dirt.

Cathedrals are, of all our buildings, those most definitely designed by architects. They are fully conscious exercises in geometrical proportion, in response to aesthetic demands. At the same time they present technical problems of great magnitude and complexity. These problems have in large measure been studied in depth, so far as regards the stone fabric, its foundations, its thrusts and buttressing masses, its resistance to weight and to wind pressure. All these aspects of architecture have received at least relatively full attention. So too have incorporated fittings of wood, such as choir-stalls and carved misericord seats, and the few timber roofs visible from below in cases where no stone vaults were intended. Visual pattern and enrichment in such cases provided the necessary clue to style and date. It seemed that there was nothing more to be said.

The impact of studies in vernacular building—the works done in traditional style by local craftsmen—has profoundly altered the picture within the last twenty years. By their nature, most works of vernacular character are undated and can be placed only in a rough order of types of development. New techniques of archaeological research are being used to make the picture more precise, and among these radio-carbon dating has received most publicity. A far greater precision can, but only in certain cases, be reached by the method of dendrochronology, the correlation of exact measurements of the annual rings of timber with the weather records of past centuries. To these two aids to study Mr. Hewett has in recent years added a third: the analysis of the many forms of joint used by the medieval carpenters to connect the timbers. Since this analysis involves close access and the probing of each joint to discover "secret" characteristics of vital importance, it is not surprising that its significance should have been so long overlooked.

In the course of a series of articles and books spread over the past twelve years, Mr. Hewett has pioneered this completely new form of research in the field of vernacular buildings. The result has been to throw into relief difficulties and inconsistencies in relation to historical chronology. The present book is the outcome of Mr. Hewett's total study of all the surviving timberwork in the cathedrals: the only class of ancient buildings generally provided with reasonably accurate dates. Much of the evidence has been destroyed in the course of restoration and rebuilding and, most tragically, by insensitive repair even within the present century. This study came, therefore, at the eleventh hour and in the nick of time. At the cost of a great deal of very hard work and much discomfort Mr. Hewett here places on record a definitive and irreplaceable study.

JOHN HARVEY

INTRODUCTION

Over a hundred great churches were built in the cathedral tradition in England during the medieval period. The historical background and course of development of this art-form, the cathedral, has been very adequately described by John Harvey, and no reiteration of the facts is necessary for this book, which is little more than a catalogue of surviving carpenters' works from England's twenty-seven cathedrals. The larger numbers of monastic churches, all of which are relevant to this study, require treatment in a separate book and only a few are mentioned—if they help to establish a course of development. Westminster Abbey is described in this way since the former roof of its northern transept was one of the few provided with branching tie-beams, of which technique more than one example is needed to make a credible case for wide advocation of that system. To quote directly from John Harvey's *English Cathedrals* (1961): "From Saxon times to the reign of Henry VIII there is no single work at any English cathedral which could be described as decadent. Sometimes inspiration flagged a little; the steps taken were uneven. But nowhere is there marked retrogression, not a work but bears plainly upon it the mark of a creative imagination." So far as the subject of this book is concerned—cathedral carpentry—that remark would only seem to hold good until the close of the thirteenth century since after that time, it seems, less permanence of construction became acceptable. Alternatively stated this means that risks were taken, as is the case with certain of the later collar-arched roofs since they have more chances of failure than did earlier well-tied designs.

The few examples of cathedral structural carpentry that we still possess cannot be regarded as safe, and the publication of a list together with some provisional assessment of their respective merits is essential as a first step towards conserving what is left for posterity. In the brief period since the end of the Second World War at least two of our cathedrals have been deprived of their timber high roofs, and the replacement of others could occur at any time since the value of things rarely or never seen, except by a few, cannot be generally appreciated—as it should be. It is to be hoped that publication of the facts as to what may yet be saved may be useful in arousing sufficient interest in the subject to ensure the safety of the little that is left.

Churches have been built in England throughout the centuries since Christianity was brought here, and among them the cathedral that contains—as it must for purposes of definition—the *cathedra* or throne of a bishop has continually been present. Evidence for this great length of the tradition is available in respect of Sherborne, Dorset, where the Abbey was until the Conquest the seat of no less than twenty-seven Saxon bishops. A cathedral tradition, therefore, existed in Saxon England and necessarily included timber roofing adequate for its purpose; but it is unlikely that anything deriving from pre-Conquest carpentry techniques survived after 1066, when the Normans built or rebuilt cathedrals as soon as they were firmly established in occupation. It is to their foreign traditions of architectural style, masonry and carpentry technique that our earliest surviving examples owe their origins. The general tradition of building great churches, however, was old enough to be highly developed at the time that Norman building operations began in England and as a result we cannot expect to find any traces of crudeness or real archaism in our oldest surviving carpentered works. The fragments at Waltham Abbey in Essex are in fact the oldest items described in this book, and they show that the church had a ceiled timber roof of superlative quality that evidently resulted from centuries of craft tradition, of a carpentry specifically designed for the roofing of churches of great size—mature and highly competent already by the third decade of the twelfth century. It seems from the evidence remaining today that this same development continued into the Norman period and at least until the general success of vaulting, and that thereafter most of the knowledge gained was readily transferable to the high-roofing series. A consistent development of ridged roofs was maintained until the middle decades of the thirteenth century, until which period no risks were taken in terms of roof-framing—each roof was adequately tied and adequately supported at intervals between its eaves and its apex—while later medieval examples left a lot at risk, being frequently without tie-beams. The dates suggested are, in many cases, merely the possibilities that are easily obtained from the most accessible publications; and either Carbon 14 dates or dendrochronological dates are necessary in every early case since these cathedrals are undoubtedly the most important architectural monuments in England. Such dates as can be obtained for them clearly should be, since there can be little justification for guessing, even in the most scholarly manner, when the precision of laboratory technology can be brought to bear on this subject.

The examination of these roofs has been undertaken as rapidly as possible since their continued existence is in many cases in doubt, and many

items must inevitably have escaped my notice. For any sins of omission I apologise and deeply regret their occurrence. My thanks are particularly due to Mr. L. S. Colchester of Wells Cathedral for his kind assistance with the dating problems of that building; and to Mr. J. H. Harvey of York whose detailed personal knowledge of the documentation of many great churches has been available to me as a result of his generosity and enthusiasm for the subject. My thanks are also due to the various deans, chapter agents, architects to the cathedrals, clerks of works, master-masons and other members of the cathedral staffs. I also thank the Cathedrals Advisory Committee, the members of which have given invaluable assistance, together with the members of my own family, who have been prepared to regard this field of study as the basis of their holidays for several years past. My wife has been invaluable as a text-reader and compiler of the Glossary, and my eldest son has efficiently planned the routes and calculated the mileages involved in this pursuit.

C.A.H.

I RIDGED MAIN-SPAN ROOFING

The earliest ridged roof examined for this study is that of Archdeaconry House at Peterborough. This building is within the precinct and very close to the Cathedral, and although not cathedral carpentry in the strictest sense it merits discussion on account of both frame design and jointing at its eaves triangulations. The chamber it roofs is probably the hall of the Norman infirmary built during the period of William of Waterville, who was abbot from 1155 to 1177.[1] The carcase of the building, containing arches, piers and capitals with some decorative treatment, is datable upon stylistic grounds to *c.* 1180, and its roof is illustrated in Fig. 1, which shows one of the single frames together with an enlarged sole-piece and ashlar-piece to explain the peculiarities at the eaves. The rafters' apexes are bridled and pegged, and the ends of both upper and lower collars are notch-lapped into the rafters. The tops of the ashlars are also notch-lapped, and the profiles of all the notched lap-joints are of the "archaic" type.[2] The bottoms of these ashlars are fitted into housings that have sinking base abutments, and pegged—a device obviously calculated to ensure their stability in the vertical position necessary for the performance of their function. The rafters' feet are tenoned into the outer sole-piece ends. All the sole-pieces are trenched across their soffits in order that they may "house" the wall-plate, which is of relatively small section and laid along the centre-line of the masonry top-course. That this roof has successfully spanned thirty feet for so long is remarkable and must be largely because two tie-beams have been inserted into it at some ancient but undetermined date.

Waltham Abbey, to judge from reconstructions made by assembling scale drawings of the timbers re-used in 1807 to make its existing roof, had a similar design to that at Archdeaconry House. This roof had a tie-beam to every rafter-couple, wall-plates set at the centres of the walls and a frame design including two collars both of which were notch-lapped at their ends. The ashlar-pieces were housed into the tie-beams and into the rafters while the lower collars were braced with notch-lapped soulaces—again the actual profiles of these notched joints is that termed "archaic". A diagrammatic reconstruction of this roof is given in Fig. 2.

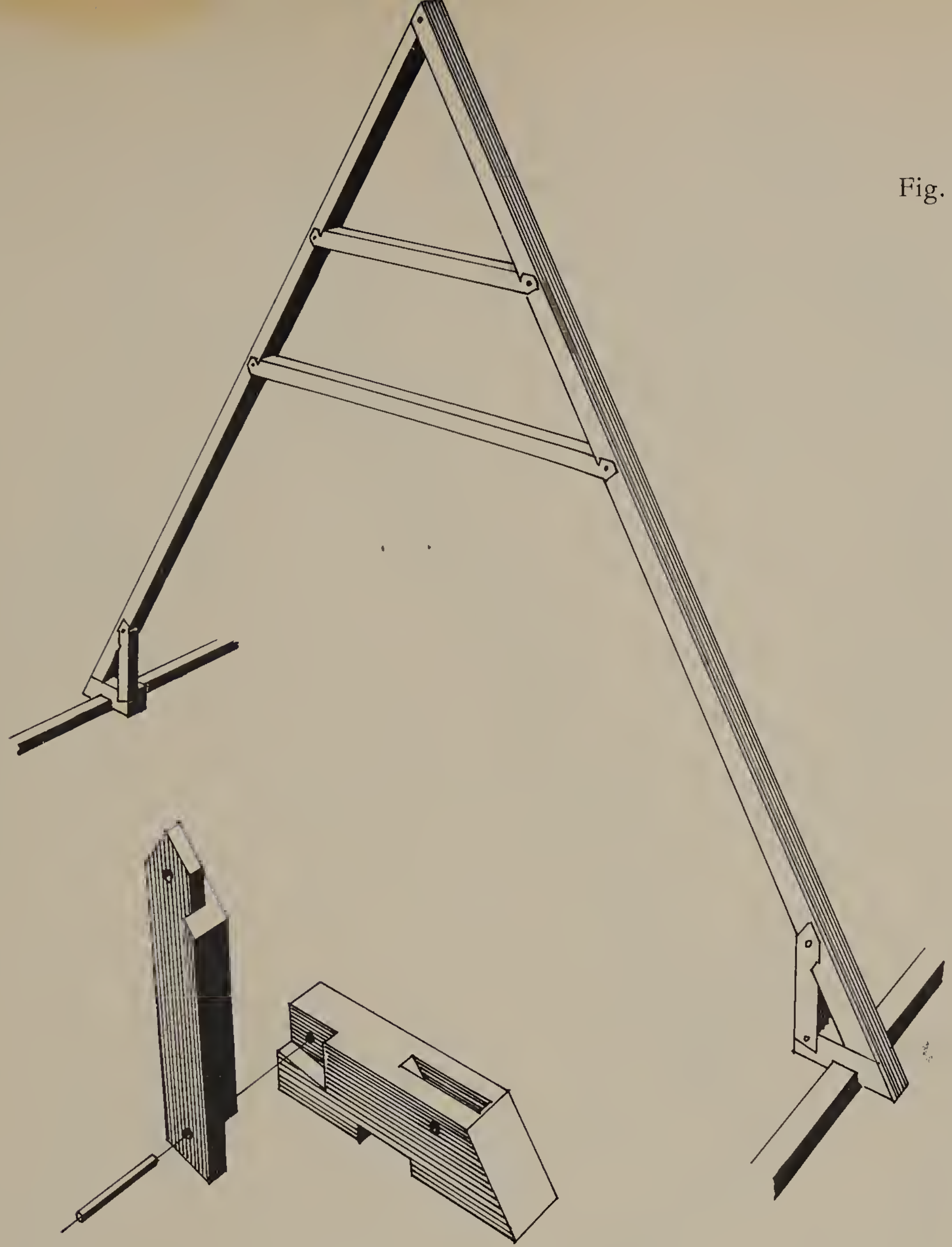


Fig. 1

The nave roof of Wells Cathedral (Fig. 3) is certainly datable to the time during which the building of the Cathedral was interrupted; this was probably the years 1209–13, when the "break" as it is called would have been co-incident with the absence of the Bishop, Jocelyn, owing to the Interdict. It is considered that work at Wells during this period would have been restricted to the upper works of then existing structures, such as the tower.[3] If this break were found to be nowise associated with the Interdict it is unlikely that its approximate dating would be much affected, since J. Bilson deduced a date of 1210 as probable. This interruption is extremely useful for the present purpose, since we cannot know when the roofing was actually begun but do know when it was halted in its progress westward, and the first part of it can as a result be ascribed with tolerable assurance to the opening decade of the thirteenth century or a date between that time and the commencement of the present cathedral—between 1176 and 1184.[4] The assurance mentioned is given by the fact that the jointing technique of the carpenter, Master

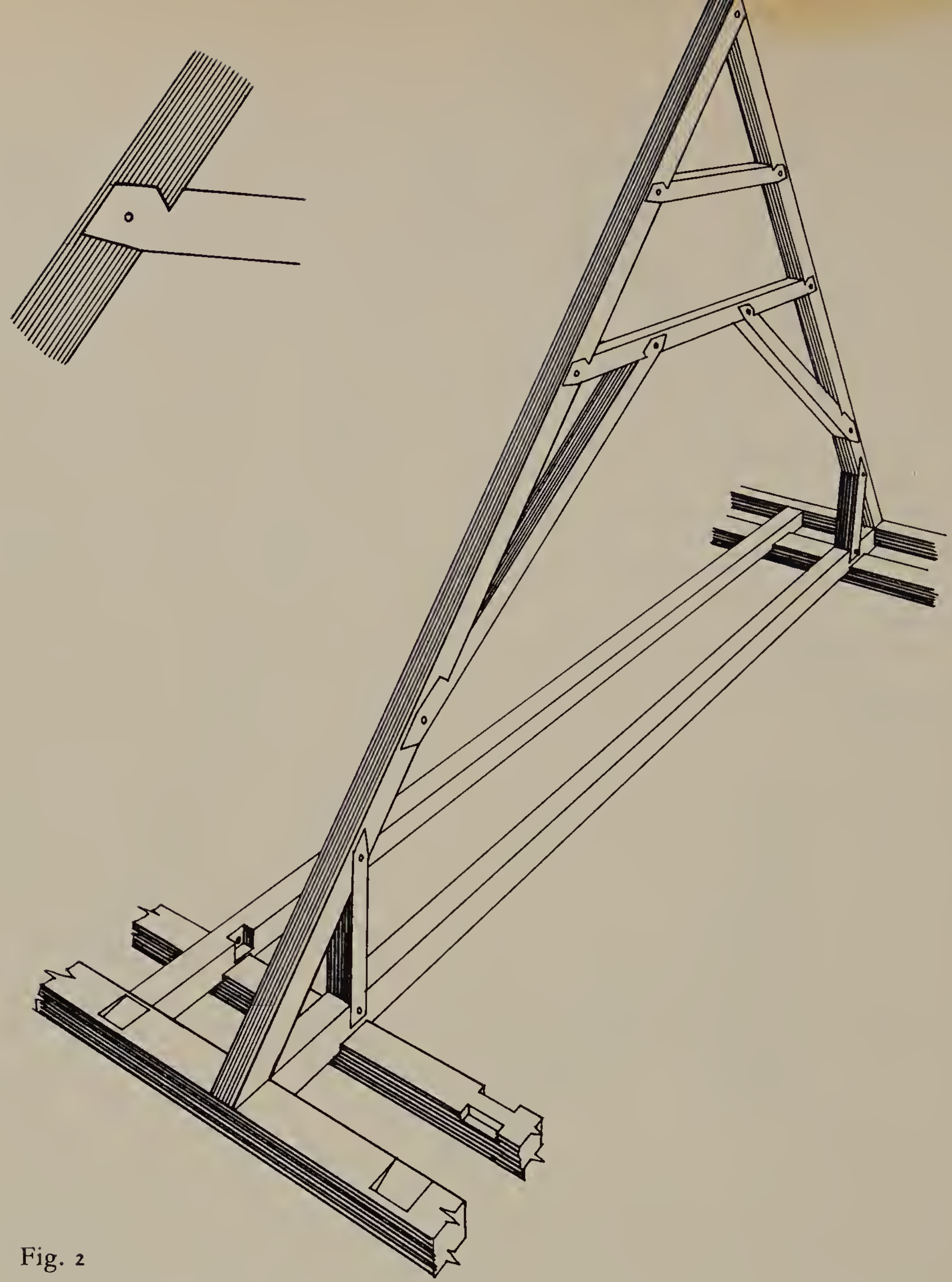


Fig. 2

Nicholas, changed very clearly during this interruption, more clearly in fact than did the technique of the masons—which last difference had been the only evidence considered until the present study of carpentry.

The drawing shows this roof as built in the first phase when it was assembled by "open" notched laps at all points except its rafter apexes. These lap-joints are among the first noted that possessed a refined profile, in which case the actual notch is given a gradual entry into the edge-plane of the timbers. There are both upper and lower collars united by vertical crown-pieces which were also notch-lapped into those collars—rare examples of this technique applied to right angles. Like all roofs at Wells this one was mutilated when the Cathedral's eaves were converted to parapets, and as a result the construction of its eaves triangles is now a matter for speculation. Tie-beams were fitted at suitable intervals, and are today embedded in the parapet masonry, so that we cannot determine

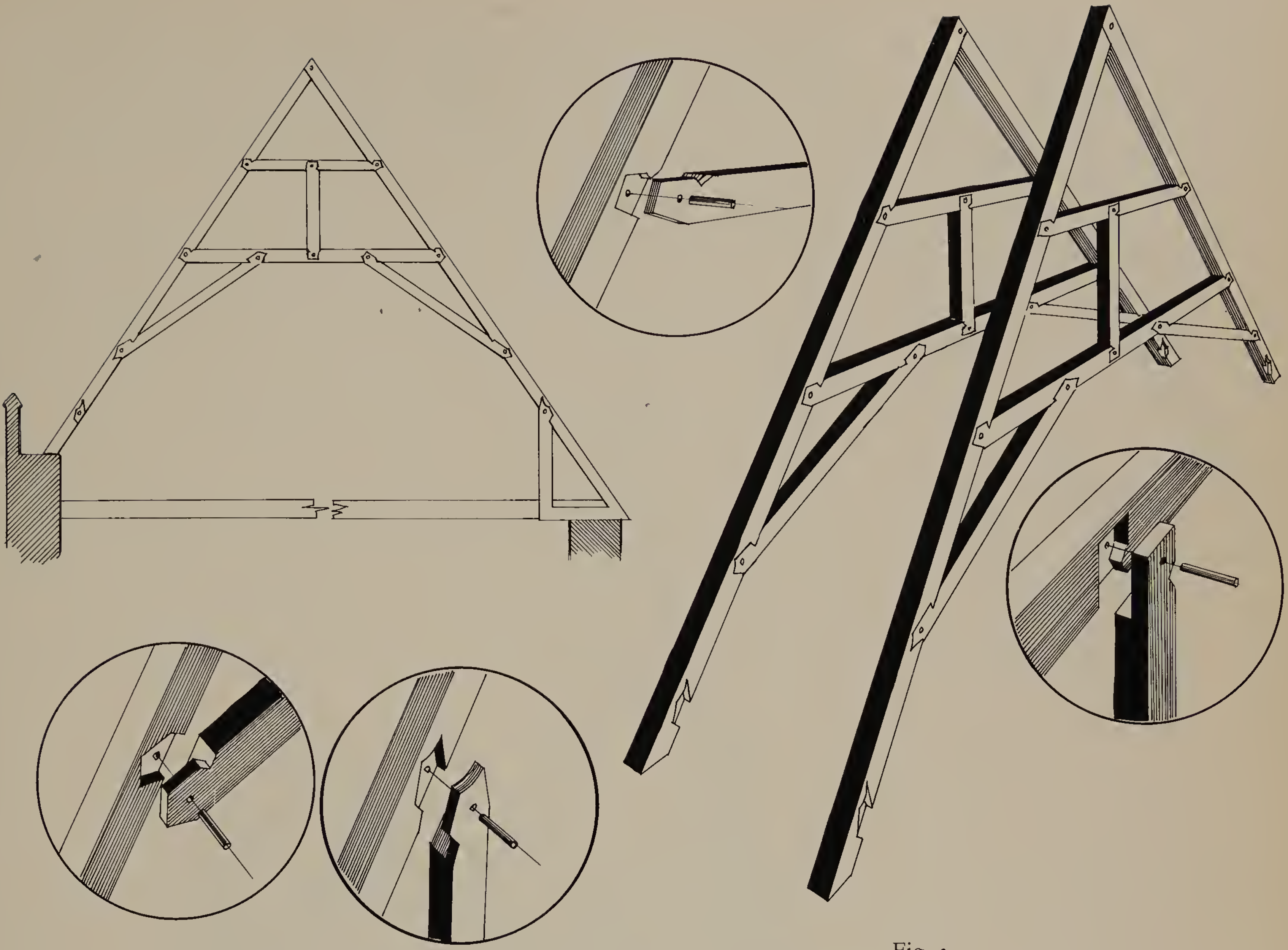
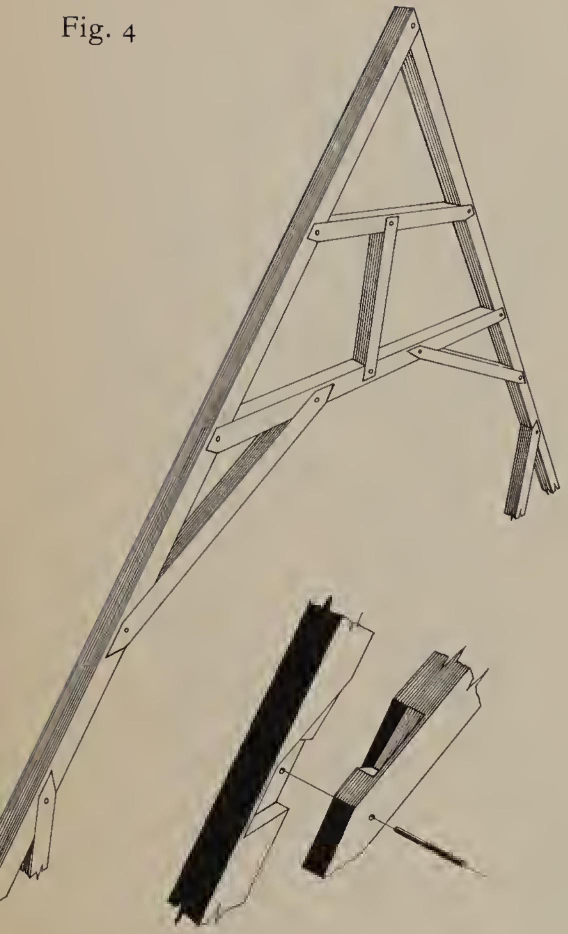


Fig. 3

the system of wall-plating. This nave was eventually continued and was completed as far as the west front *c.*1229. The roof-frames used during the second phase of building were identical to those of the first phase but for the adoption of "secret" notched laps at all points except the crown-pieces where secret barefaced lap-dovetails were used. This phase is illustrated by Fig. 4.

Of less certain date is the fragmentary roof illustrated in Fig. 5, comprising seven rafter-couples, all re-used to provide a roof to the north-west portico of the Peterborough west front—completed by *c.*1230.[5] These frames were first recorded by Reinhard Reuter,[6] who ascertained that if given rafter feet and eaves triangles—for all of which clear evidence survives on the timbers—they would span the nave of the Cathedral and that their pitch of 52° would suit that situation in the fabric. The drawing omits the timber ceiling of this nave, which is also of the twelfth century,

Fig. 4



and the structural association of ceiling with the roof-couples still awaits analysis. Were this hypothesis proven the roof-frames would date from the building and completion of the existing nave, between *c.*1155 and 1175. The design and jointing by means of notched laps and sidewise assembly, the laps being of the archaic form, would not conflict with such a date ascription.

The eastern transepts of Lincoln Cathedral were completed by 1200, and it is possible that its existing northern high roof is of that date and no evidence to the contrary. This roof is singly framed as shown in Fig. 6, which gives one complete frame and wall-plates together with an "exploded" view of the complex assembly at the eaves triangles. As can be seen, this construction is highly refined and its jointing uses notched laps in only the most appropriate position—the feet of the scissor-braces. The southern transept at Lincoln was also complete by 1200, but its high roof (Fig. 7) differs considerably from its northern counterpart. This last roof closely resembles most of the other apparently original roofs of Lincoln, and it has to be determined whether it is derived from, or how it relates typologically to, the northern roof. The long and in-canted ashlar-pieces of the north roof were in the south roof replaced by truncated

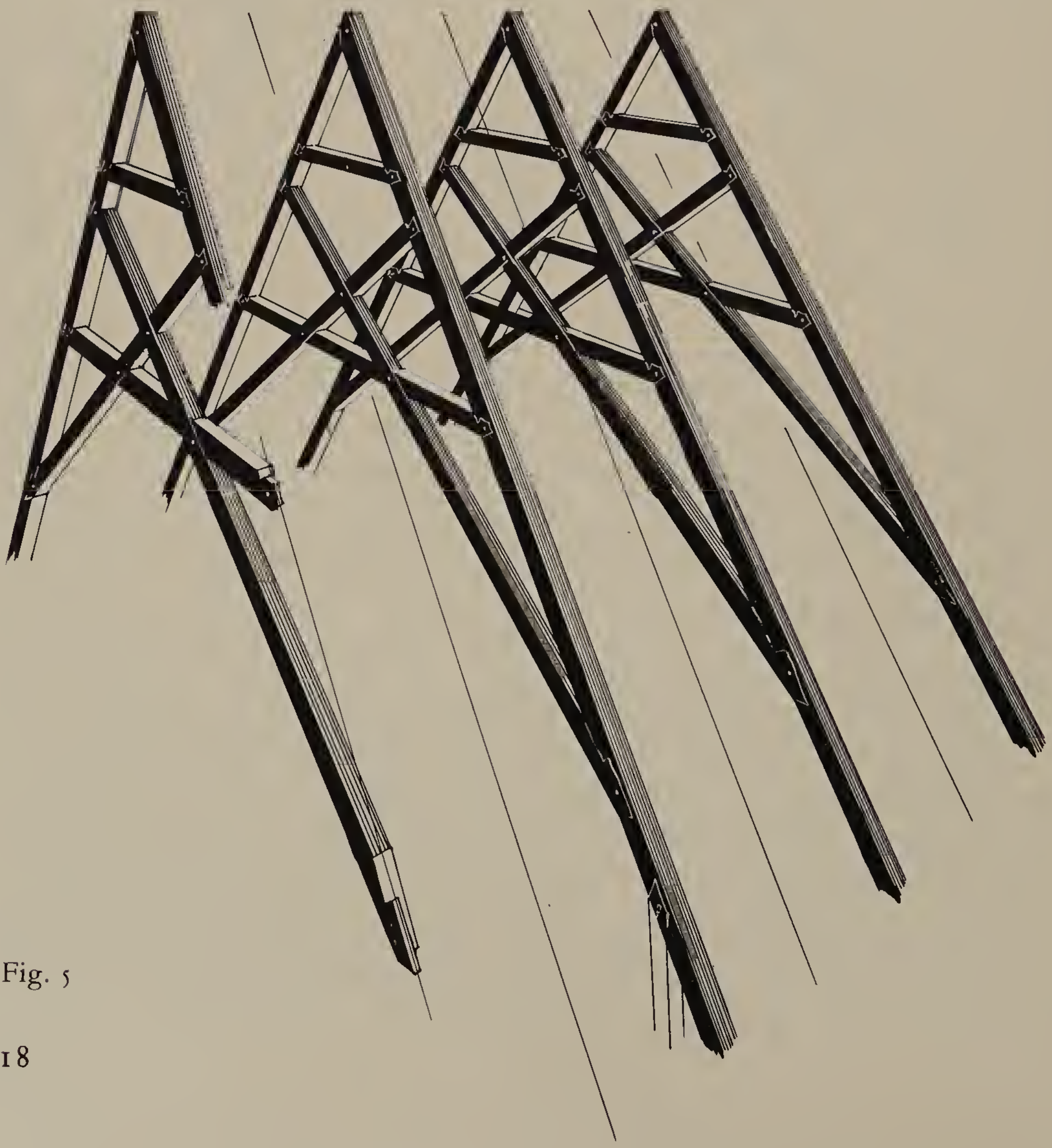


Fig. 5

secondary rafters that tenon into both collars and soles; and the scissors were replaced also, by notch-lapped soulaces which very shrewdly pass the intervening secondary rafters entire—producing an apparently unopenable pair of feet for the rafter-couple. The spaces enclosed above and beneath the high collars were regarded as subject only to compressive stresses. The timbers housed over the successive tie-beams, which were placed at every fourth couple, may also be original and, if they are, bring this assembly within the double-framed category.

A smaller roof at Lincoln is that of the chapter-house vestibule (Fig. 8). This was assembled largely by tenoning, but notched laps were used for

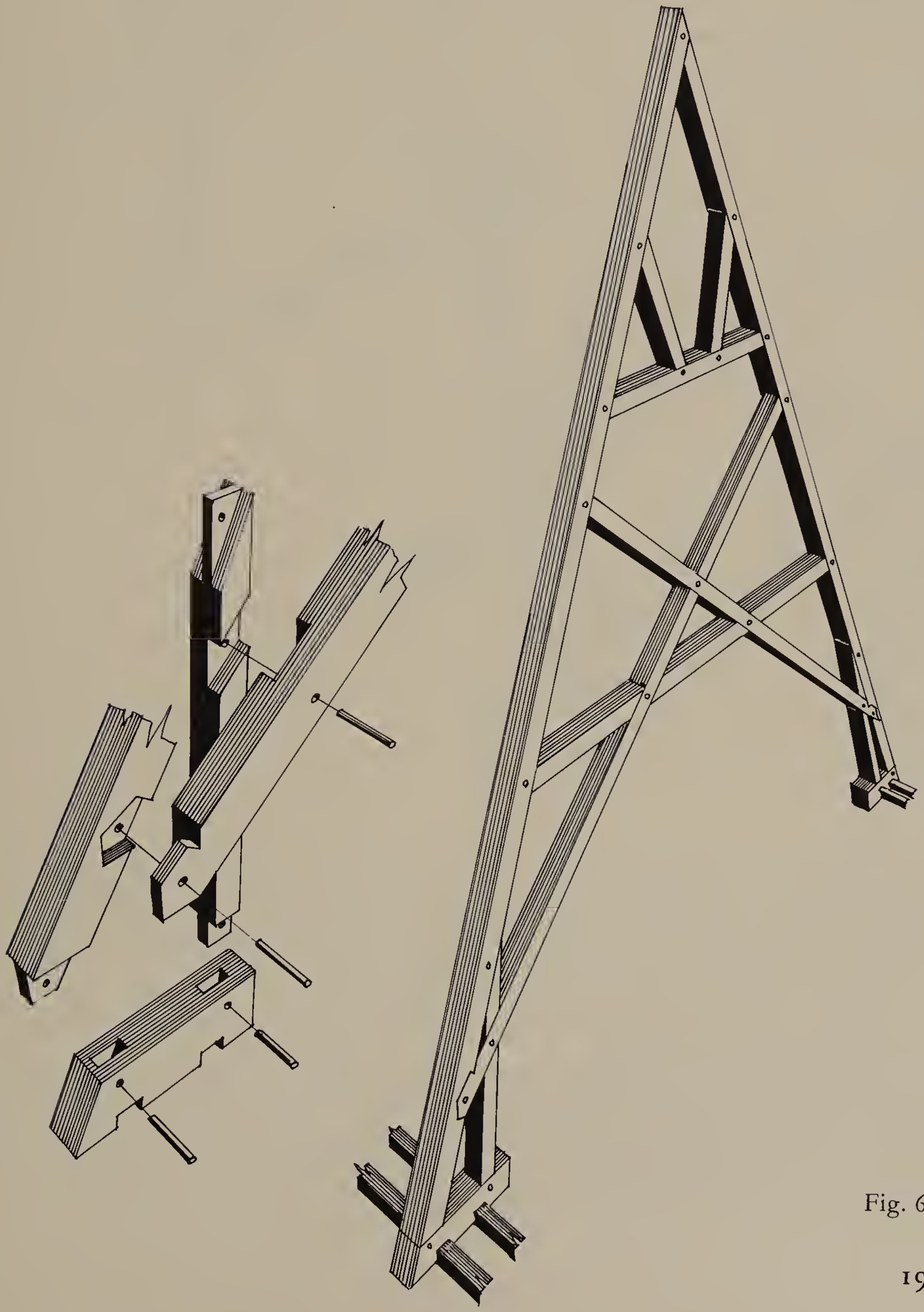


Fig. 6

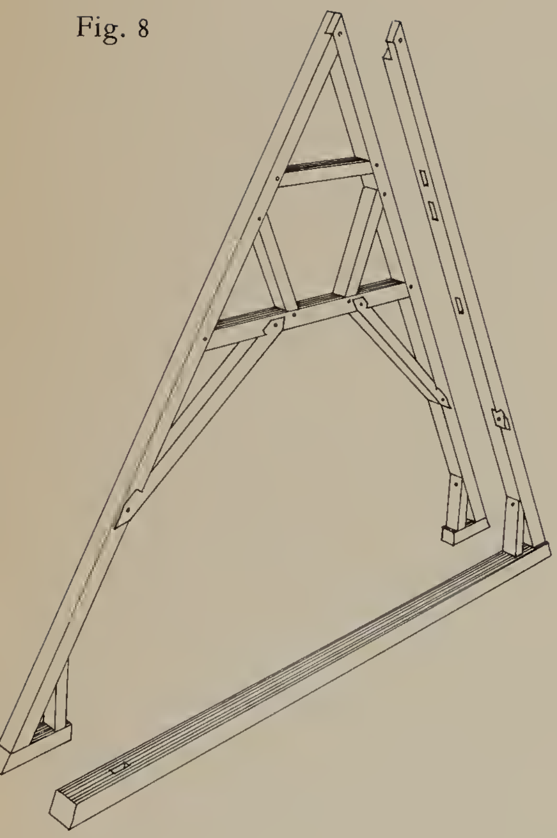


Fig. 8

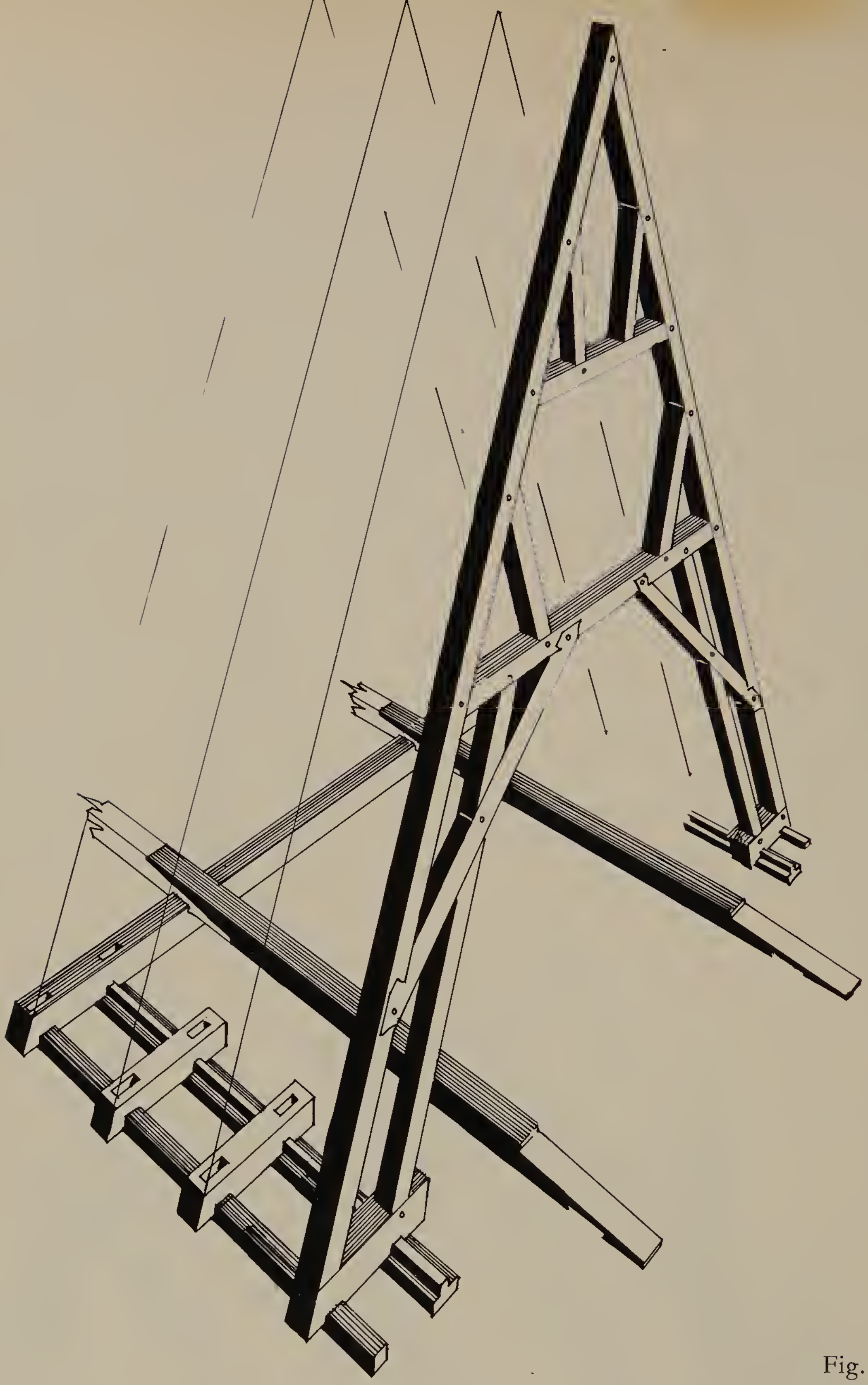
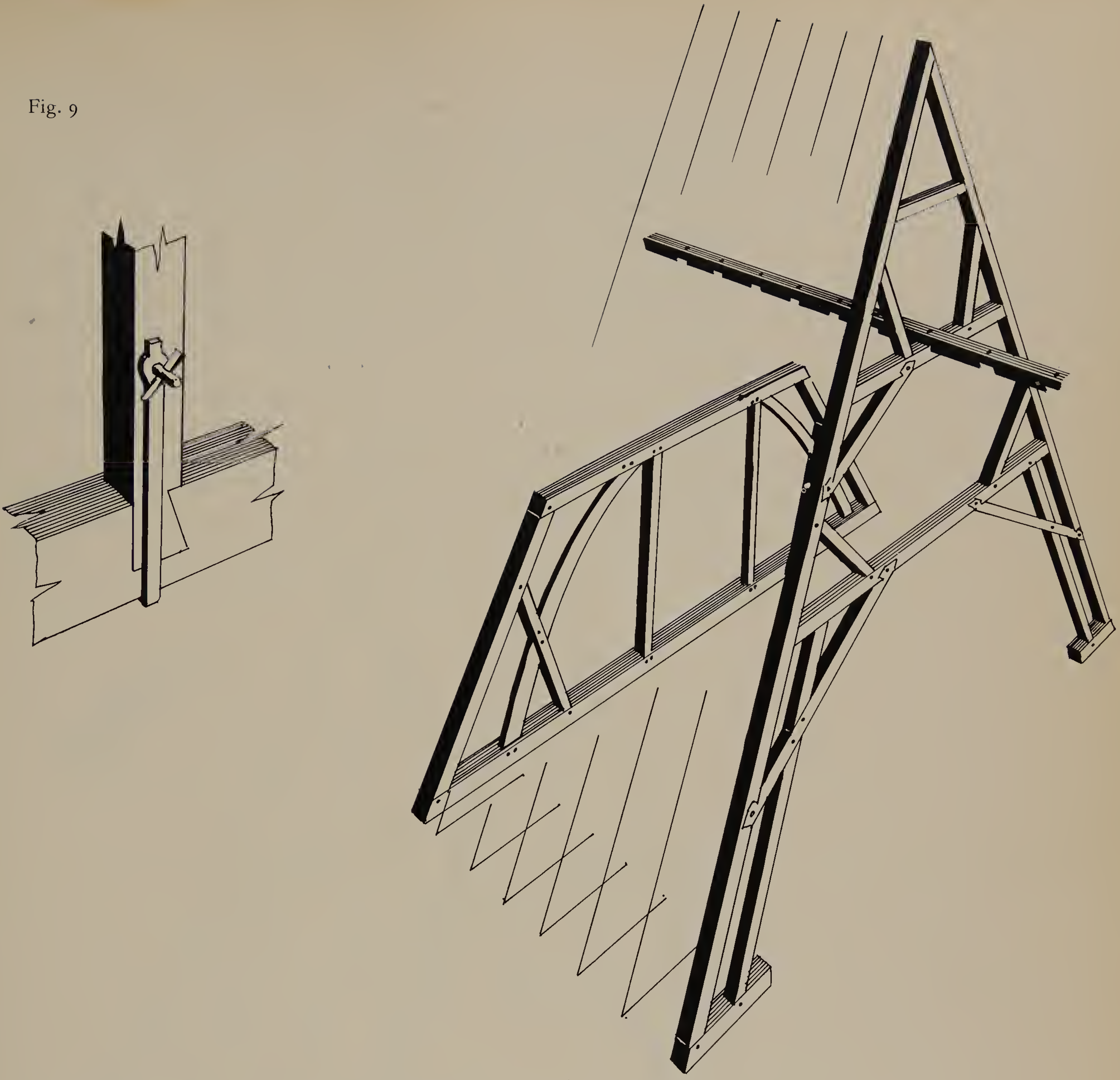


Fig. 7

the soulaces and tie-beams were fitted, again, to every fourth couple. No traces exist of any wall-plates to this structure. The work of building the Lincoln chapter house, and presumably its vestibule, covered the years *c.*1220–35 and was directed by Master Alexander.

Master Alexander was also architect of the nave of Lincoln which, according to John Harvey,[7] covered the period from *c.*1225–53. This roof is shown, in part, in Fig. 9; and while it closely resembles the others at Lincoln it possesses the peculiarity of a collar-purlin that is housed over the collars, in succession. The truncated frames, of which an ex-

Fig. 9



ample is shown in the figure (9), are interspersed along the length of this nave and are intrusions since many were squeezed in between the earlier and original couples. The intended function of these intrusions is not clear, but the jointing of one of them is shown with its iron strap and forelock bolt—to complete the record.

A roof of most uncertain date, that shown in Fig. 10, is that of the south transept at Wells, in which case the use of "bent" timber was introduced—as it was also in the northern transept and the quire roofs of that cathedral. It is known that the eastern arms of Wells—quire and both

transepts—were begun *c.*1190, but how long thereafter their existing roofs were built cannot be estimated.

That two of them were converted at the time of the parapet-building operation is evident, however, and so we may be sure that they pre-date the middle decades of the fourteenth century. The rafters' feet were cut off at this time, as shown in the drawing, and they were stood directly on an additional course of stones with the remainders of their sole-pieces left in position. The drawing shows one bay, in this case comprising four couples, with an enlarged view of a raking-strut as used to trap the side-purlins of the roof.

Another roof, this time an open one whereunder no vault seems to have been intended, that also featured bent timber was building at Lincoln during the opening quarter of the thirteenth century, survives until today and is that of the church of the Grey Friars. The friars obtained

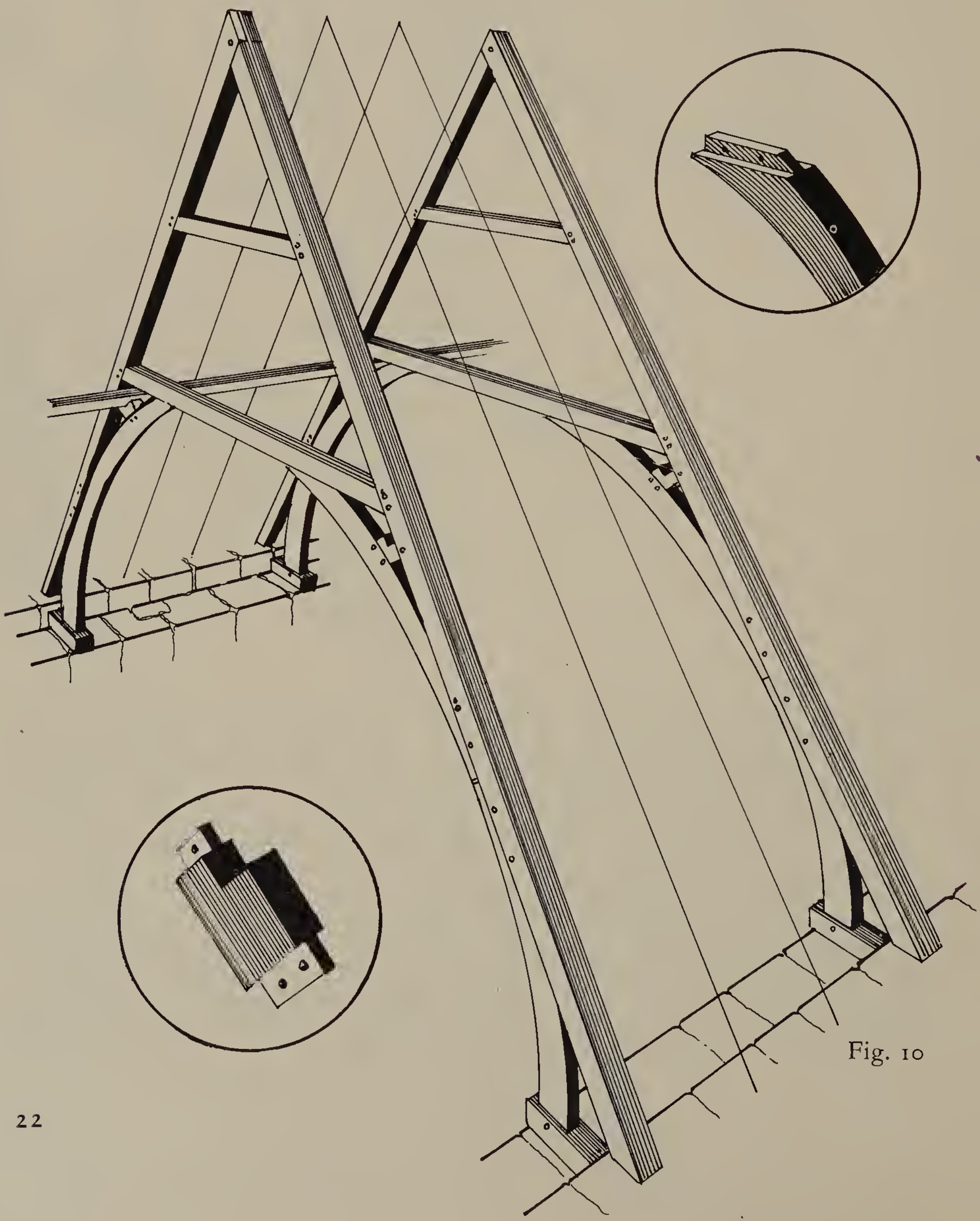
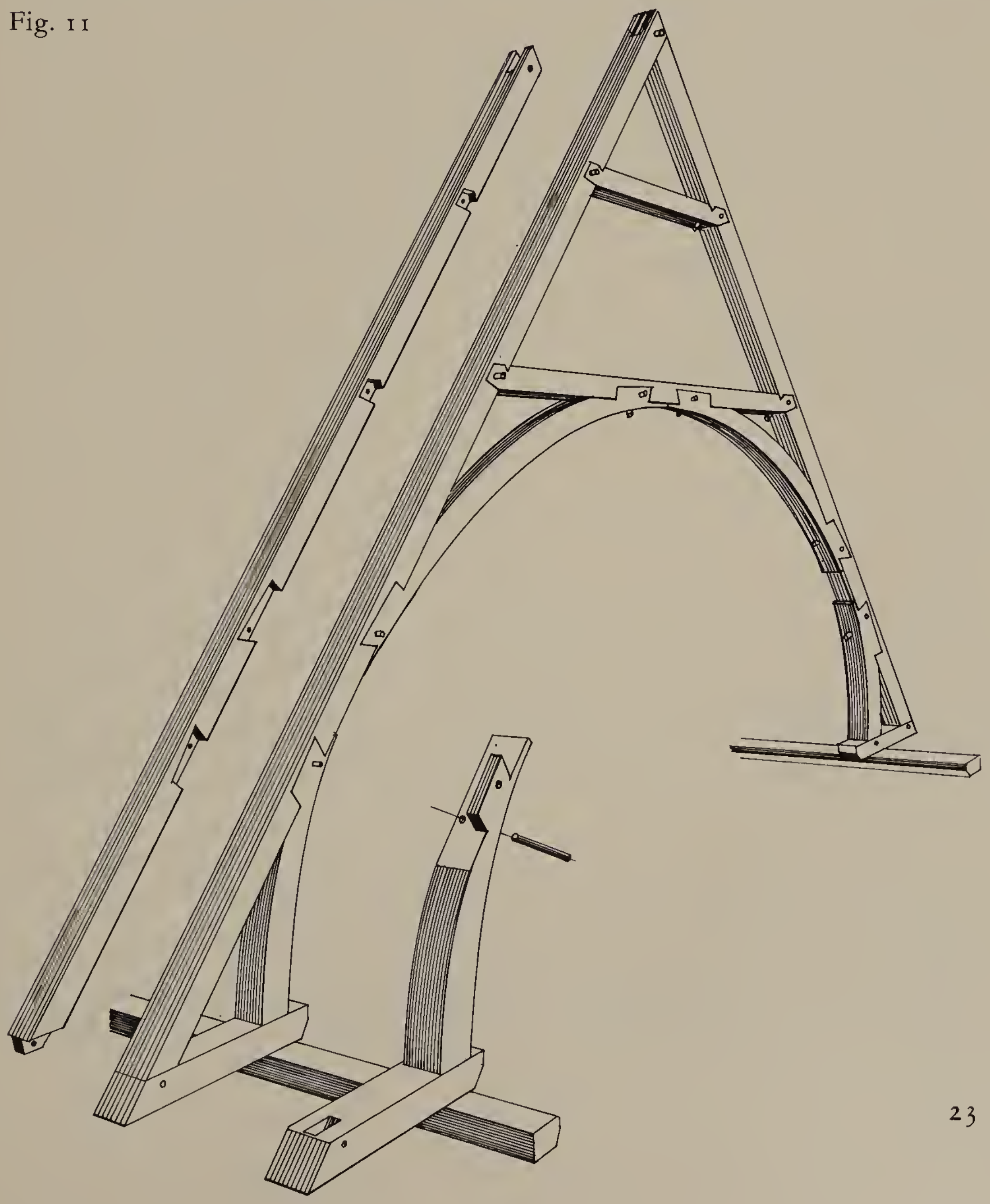


Fig. 10

their plot of land near the guildhall as a gift from the citizens of Lincoln in 1231, and from the terms of the gift it is clear that they had previously settled on an adjacent site given by the sub-dean.[8] At some time, possibly before the gift of land in 1237, the friars began to build their chapel—commencing at the east end and progressing westward. The roof to the eastern end which has survived is built into a completely semi-circular curve that is formed by four separate timbers, all of which are fitted into the rafters with open notched laps, as are the upper and lower collars. This assembly is shown in Fig. 11.

This was another building that had its progress interrupted, but in this instance the date of the interruption is less certain; it is thought to have been *c.* 1260. This break is, again, of much interest and for the same reason as the one at Wells, namely that the type of construction changed during the interval and the roof-couples belonging to the second phase are scissor-braced and straight, but still jointed with notched laps. There are twenty-eight feet of this second roof comprising seventeen couples,

Fig. 11

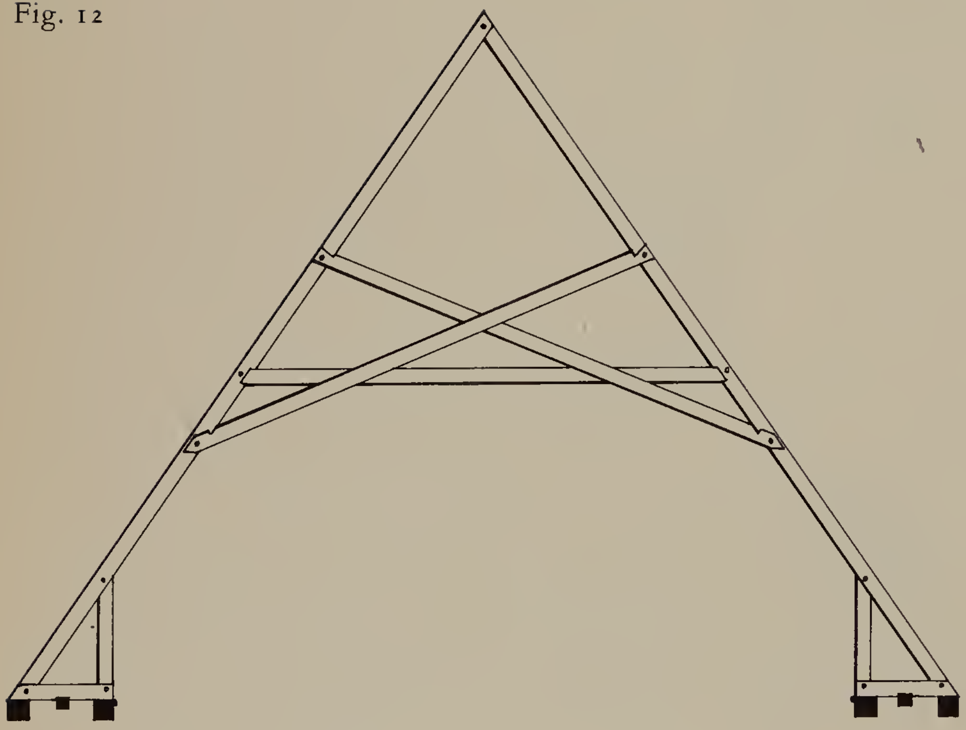


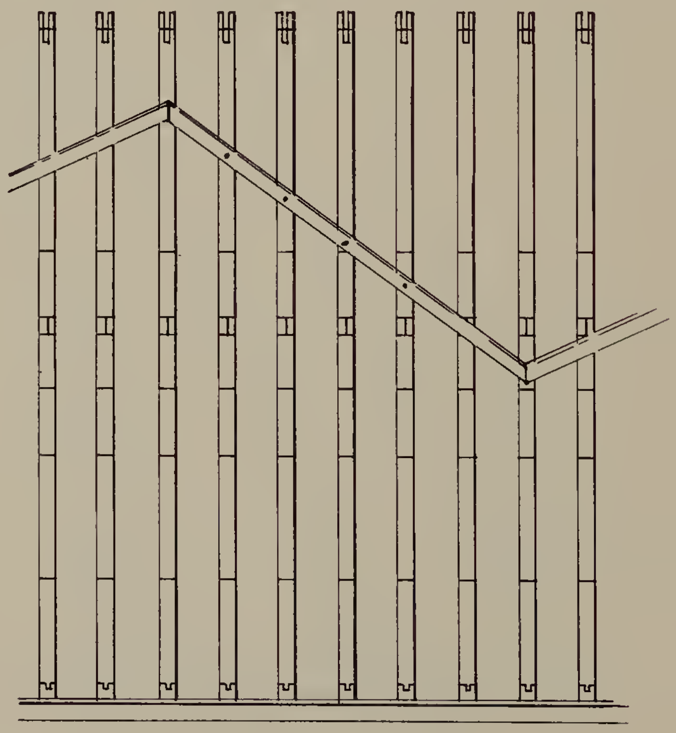
which can be ascribed to the third quarter of the thirteenth century.

At Gloucester the Black Friars also built a church, having become established there in AD 1239. Royal grants cover the years 1241 until *c.*1265,[9] by which date it was probably completed. The roof shown in Fig. 12 is that over the nave; it is scissor-braced with open notched laps at the scissors' feet, and a very elaborate system of wall-plates totalling three. It is possible that this roof was intended to be thatched since slots exist on most rafters for holding battens in the manner recorded at Ely in respect of the west range there.[10] Perhaps the most important feature of the roof is the wind-bracing, which is spiked to the rafters' undersides; the spike-heads are driven into shallow square counter-sinkings, which technique relates them to the spikes of the west doors of Salisbury and of Wells; and they are clear evidence for carpenters showing some concern over the problems of roofs "racking" along the lines of their lengths during the thirteenth century.

The high roofs of Exeter Cathedral are of great interest, but the history of that church is long and complex so that the interpretation of the documents needs great care if the surviving carpentry is to be attributed to the known periods of building activity. The present site had anciently been one devoted to Christian worship, having had a minster upon it in AD 932 during the reign of King Athelstan. Later a "great cathedral" was built on the site and in the Norman style. This building was presumably begun at the east end in 1112, seriously damaged in the seige of Exeter in 1136 and eventually completed, at the *latest*, in the time of Bishop Henry Marshall (*c.*1185–90). Subsequently a new Gothic church was

Fig. 12





begun at the extreme east end in *c.*1275, and the high building of the presbytery was definitely begun in 1288. Work moved westward to the crossing and one bay into the nave by 1317 and would have been timber-roofed as it was completed. More timber, including forty-eight great oaks, was purchased between 1323 and 1326—implying that the frames were prepared in advance of the building and reared as the latter progressed westward. At this point I quote J. H. Harvey directly:

> There is clear structural evidence that the Norman nave was much lower than the present one, hence the old roof (of *c.* 1140–90) must have been taken down, and if any of it was re-used, it would have had to be a re-framing at the new higher wall-top level. As the master throughout this period (certainly to 1340) was Thomas Witney, one of the few proven examples of an architect who was both mason and carpenter, and an outstandingly advanced designer, one would not really expect any re-use, but rather a brand new roof designed *c.* 1325. To sum up: the only timber roofs made at Exeter Cathedral for the high main-spans would belong to the periods:
>
> 1. The whole Norman church—not earlier than 1115–20; very likely not before 1140; must have been *finished* by *c.* 1190–1200.
>
> 2. The eastern part of the present church, from above great east window to the crossing (between the Norman towers), and probably including one bay of the nave to the west of the crossing, all between *c.* 1290 and *c.* 1310 in two sub-sections.
>
> *(a)* the four eastern bays, roofed before 1300;
>
> *(b)* the $3\frac{1}{2}$ bays of Choir, plus crossing, plus (presumably) the nave bay to the west of the crossing, *c.* 1310.
>
> 3. The nave (except east bay), designed *c.* 1325 and probably all in position by 1342 (canvas was bought to make a temporary blocking of the great west window; this makes sense only if the timber roof was already up; the vaulting in stone is later, as usual).
>
> There is one absolutely precise date: the wooden vaults in the transepts (towers) were made in 1317.[11]

It is possible to reconcile the surviving roofs with this information, and the single roof-couple shown in Fig. 13 is one that is representative of all the couples in the eight eastern bays, above the high presbytery; they are scissor-braced with open notched laps and small raking-struts that support the side-purlins. These couples could well pertain to the Norman church of *c.*1190–1200.

The next roof design, to the west of the last mentioned, is shown in Fig. 14. This is of a fine doubly framed type incorporating short, tenoned collar-purlins four couple-interstices long which are jointed into the crown-pieces. This type extends the greater part of the length from the scissored and notch-lapped couples to the western gable; and while con-

Fig. 13

tinuing the side-purlins it also mounts the central collar-purlin. A peculiarity of both designs is their method of wall-plating, they employ short timbers which were tenoned into each succeeding sole-piece and against which the next couple could be reared—a system enabling the roof to proceed westward a couple at a time, as the upper string-course was prepared for them. This same system has already been recorded at the parish church of East Ham in Essex, which is ascribed to *c.*1130.[12] In the case of the eastern, scissored couples, the side-purlins were inserted after the rearing of several couples; while during the rearing of the western series the collar-purlins were fitted every fifth couple—stabilising the intervening pairs, their side-purlins being fitted later.

The two transeptal roofs leading to the flanking towers, towers which are survivals of the Norman church, are built as shown in Fig. 15. Similar to the nave roof at its western part, their valleys are effected by means of valley-boards—shown in the drawing. One new and fascinating joint was introduced in these roofs where the vertical struts cross the lower collars to trap the side-purlins; this may be defined as a "counter-sallied cross-halving". This joint is ringed on Fig. 15, and should require no further explanation. The difference between the scissor-braces of the first phase and those of the later phases is twofold; firstly at the east end

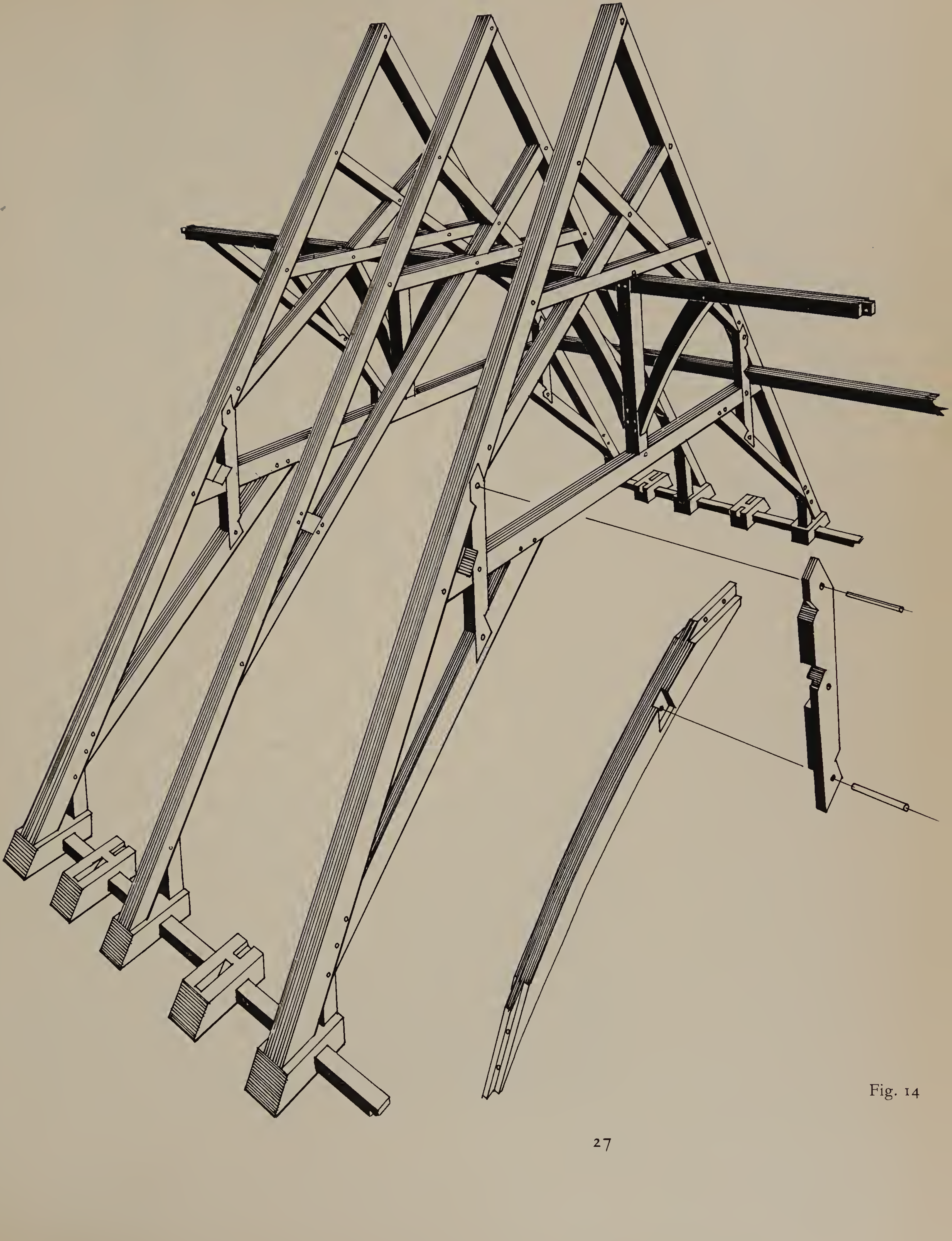


Fig. 14

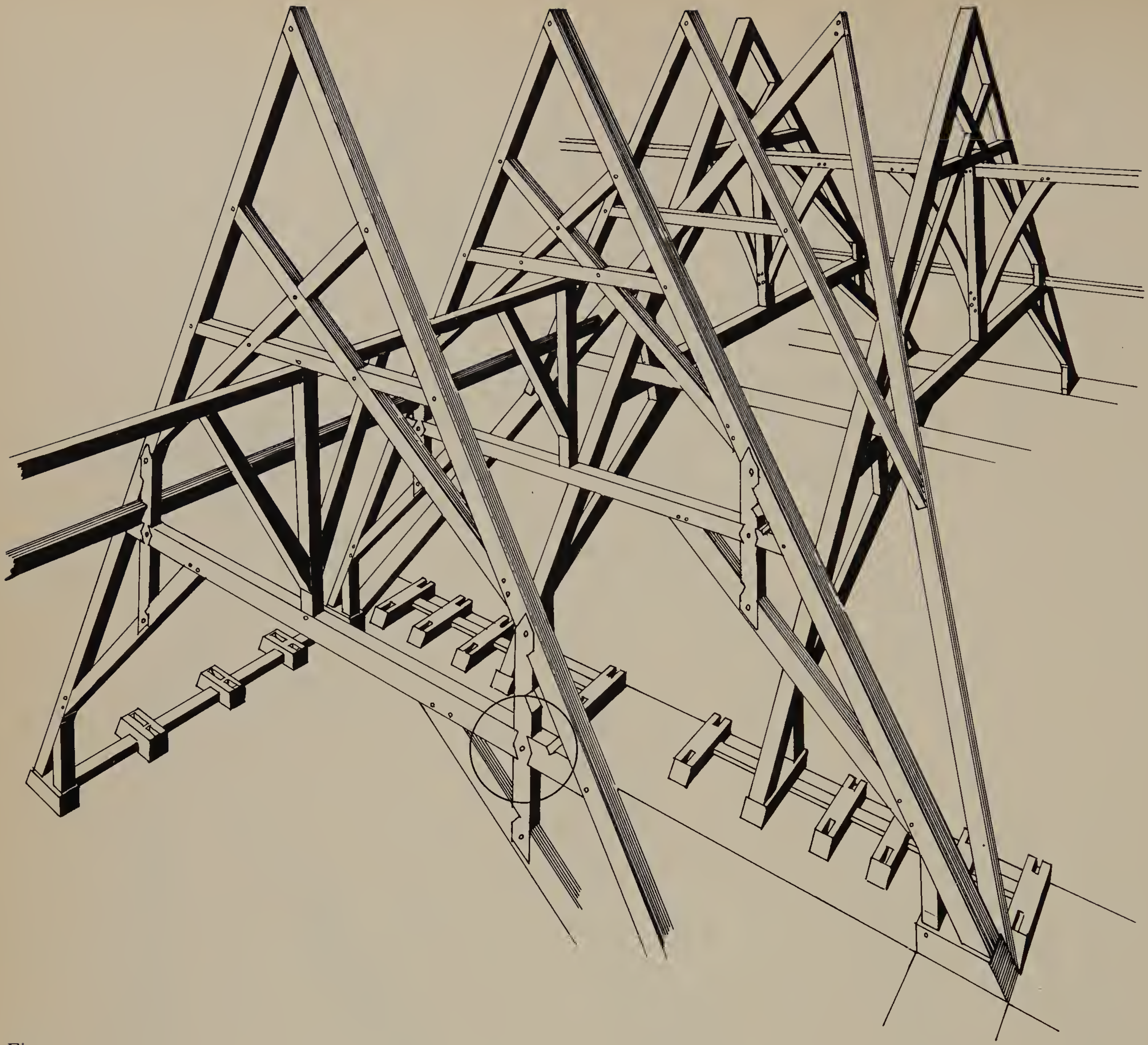


Fig. 15

they tied the rafters' feet by notched lap-joints which crossed the single collars; and thereafter they were raised to a position crossing the upper collars, in which they resisted compression by means of chase-tenoned ends. Both their position and their function were therefore changed between *c.*1190–1200 and *c.*1310.

The high roof of Chichester Cathedral (Fig. 16) is continuous for the whole length of that church and is interrupted only by the crossing tower; the bay shown in the drawing is that at the western end. The collapse of the central tower and spire in 1862 evidently did little damage to the roof, and the few repairs needed after that event are clearly visible. Apart from that well-documented disaster nothing is recorded that would have necessitated re-roofing the Cathedral, except for the great

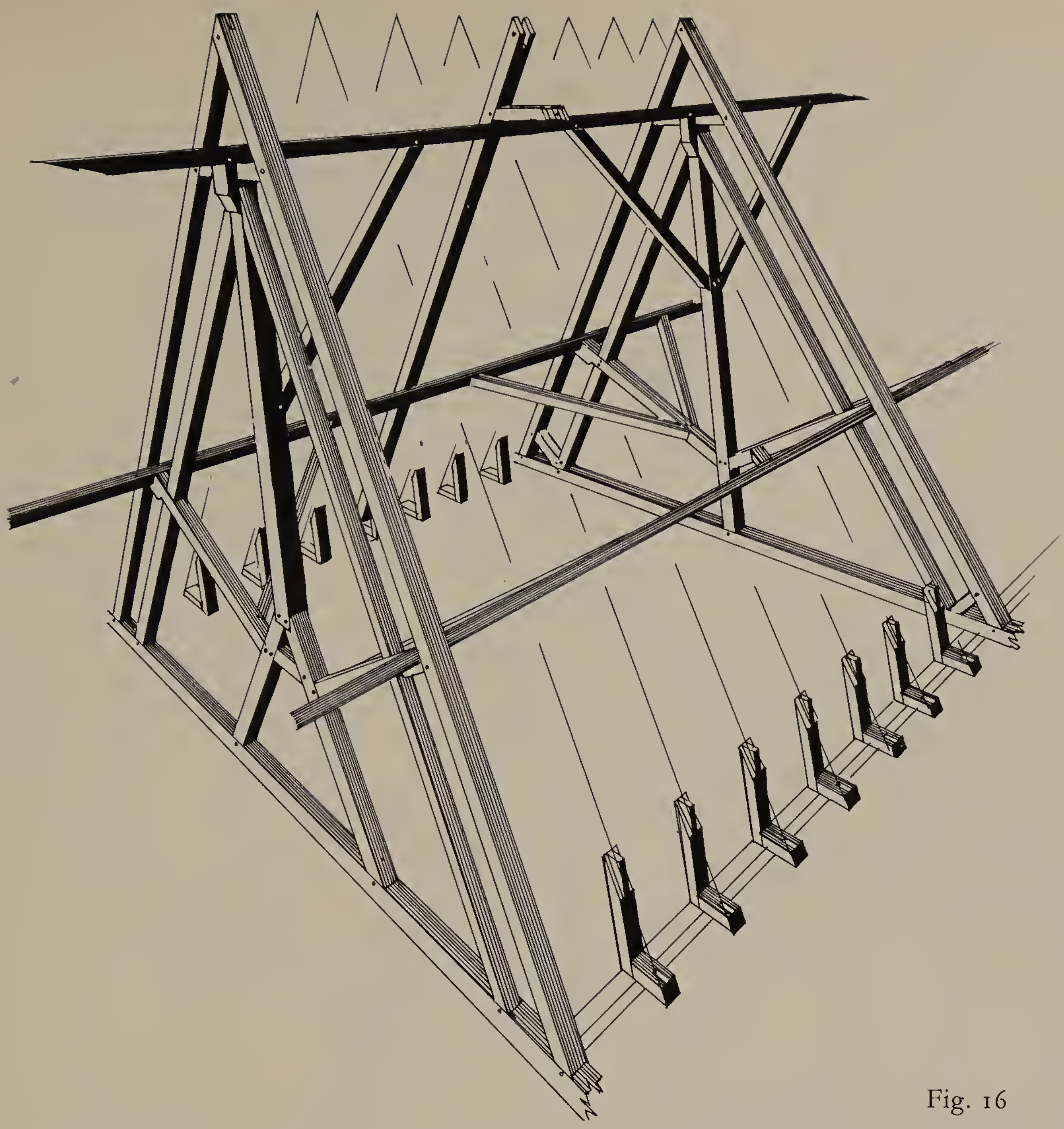


Fig. 16

fire which broke out on 20 October 1187, after which Bishop Seffrid repaired the building and added the stone vaults, this work being completed by 1199 when the great church was reconsecrated. This roof is unique among those surviving in English cathedrals today, and comparisons are therefore limited. Fortunately, Professor W. W. Horn has published a strikingly similar specimen which roofs the abbey barn of the Cistercian monastery of Maubuisson (Seine-et-Oise) in France.[13] This roof appears to be identical in design and jointing, and has been carbon dated to between *c.*1050 and *c.*1220. (Carbon dating is normally more explicit than this, and the full context of the loose date-ascription is cited in the note.) The monastery is believed to have been founded in 1236 by one Blanche de Castille. It remains to be determined whether Chichester has a roof of similar date or an earlier example of the same design. A carbon dating is essential to resolve the question.

The high roof of the north choir transept of Salisbury Cathedral is apparently the original one for that arm of the building and is the only

roof at that cathedral which has not been replaced. The date given by J. H. Harvey for the completion of the choir is 1237,[14] and it is probable that the eastern transepts were also complete at about the same time, according to Canon A. E. Smethurst.[15] The Cathedral was finished in the main and consecrated in September 1258, and having been built in the normal direction from east to west we may assume this transept to have been completed early in the period. Two bays of this roof are illustrated in Fig. 17, in which its structural elegance and efficiency can be studied.

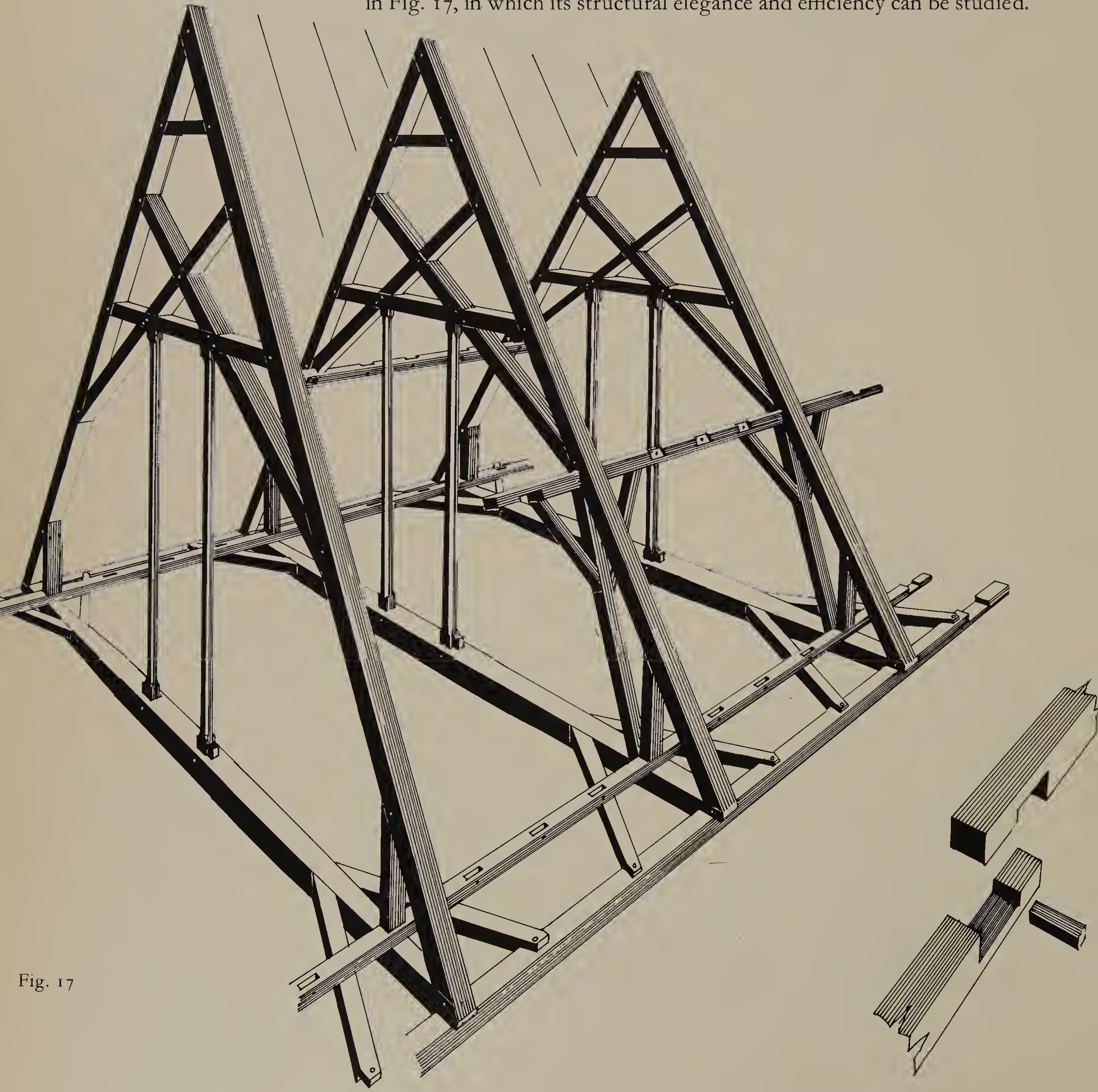


Fig. 17

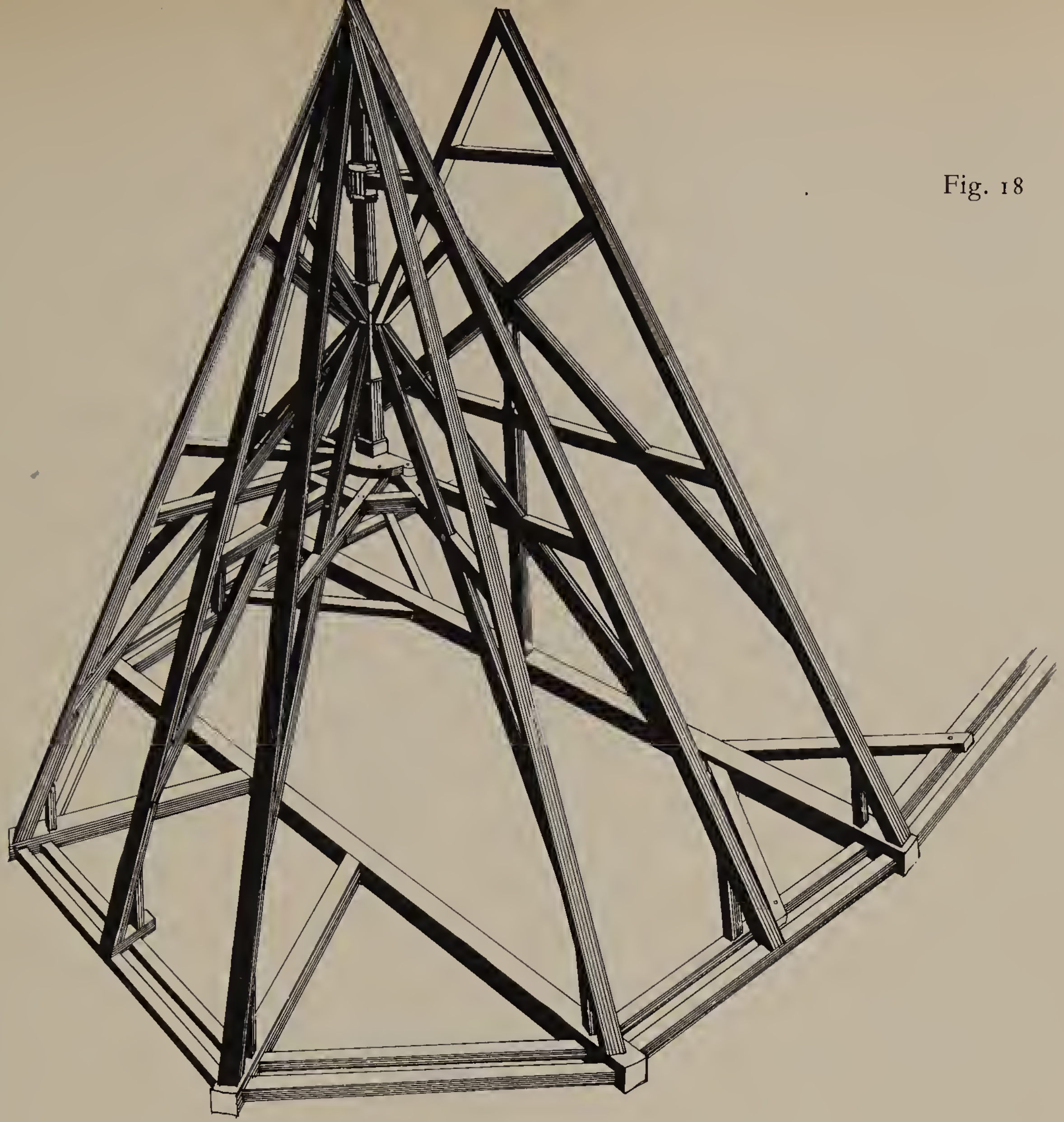
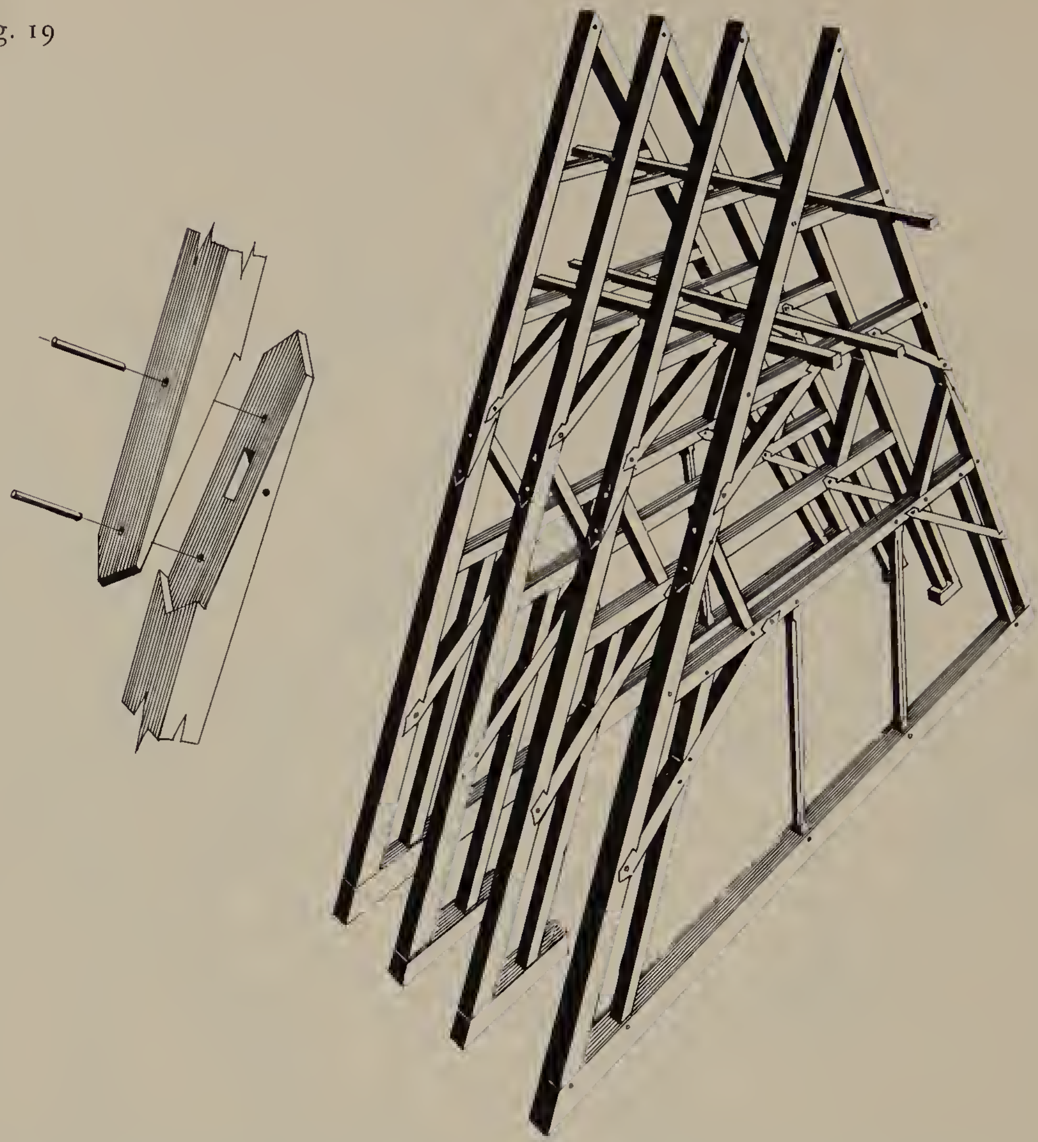


Fig. 18

The tie-beams in this example continued to be closely spaced and occur at intervals of every fifth couple; they also show the refinement of tapered ends that branch into diagonal ties, very effectually preventing all wall-plate spread. These diagonal ties seem to be fitted by "secret" notched laps—joints used most sparingly by the architects, Elias of Dereham and Nicholas of Ely, to whom this work is attributed. Above these diagonal ties the inner wall-plates are mounted and serve to carry the ashlar-pieces, being trapped in position by the canting-posts fitted to support the side-purlins. The purlins, in turn, are supported by diagonal braces from the posts and are arris-trenched in order that each individual rafter might be prevented from racking in either direction. In addition each principal frame has two posts, of octagonal cross-section, tenoned into the tie-beams, which mount the collars; while scissor-braces are fitted that form the ultimate phase of development for such braces, being formed out of five short timbers chase-tenoned into a saltire assembly. This is the earliest case known to me of this type of scissors, which is found and has been recorded in several Essex parish churches.[16] The scarf joint shown in the drawing is the one used throughout the original

Fig. 19



carpentry of Salisbury and has been seen only in the nave of Winchester outside that context.

A further example from the middle of the thirteenth century is provided by the next roof (Fig. 18), which is the high roof of the east apse of Westminster Abbey, with the common rafters removed for the sake of clarity, and Fig. 52 shows the same assembly viewed from the opposite direction and with more components left out to clarify even further. The documentation of this roof deserves mention before its construction is assessed, because fairly definite dates are published for this work.[17] The rebuilding of this church was begun in 1245, and its eastern arm with two transepts was complete by 1259; and further detailed records indicate only a long succession of repairs and no re-roofing, so we may conclude that the carpentry is the original. No further research, however, will now be possible since a complete restoration is currently being concluded, but nevertheless all timbers in the apse above eaves level are being very carefully restored. As these roofs last stood before present works were carried out that of the north transept had rafter wind-bracing

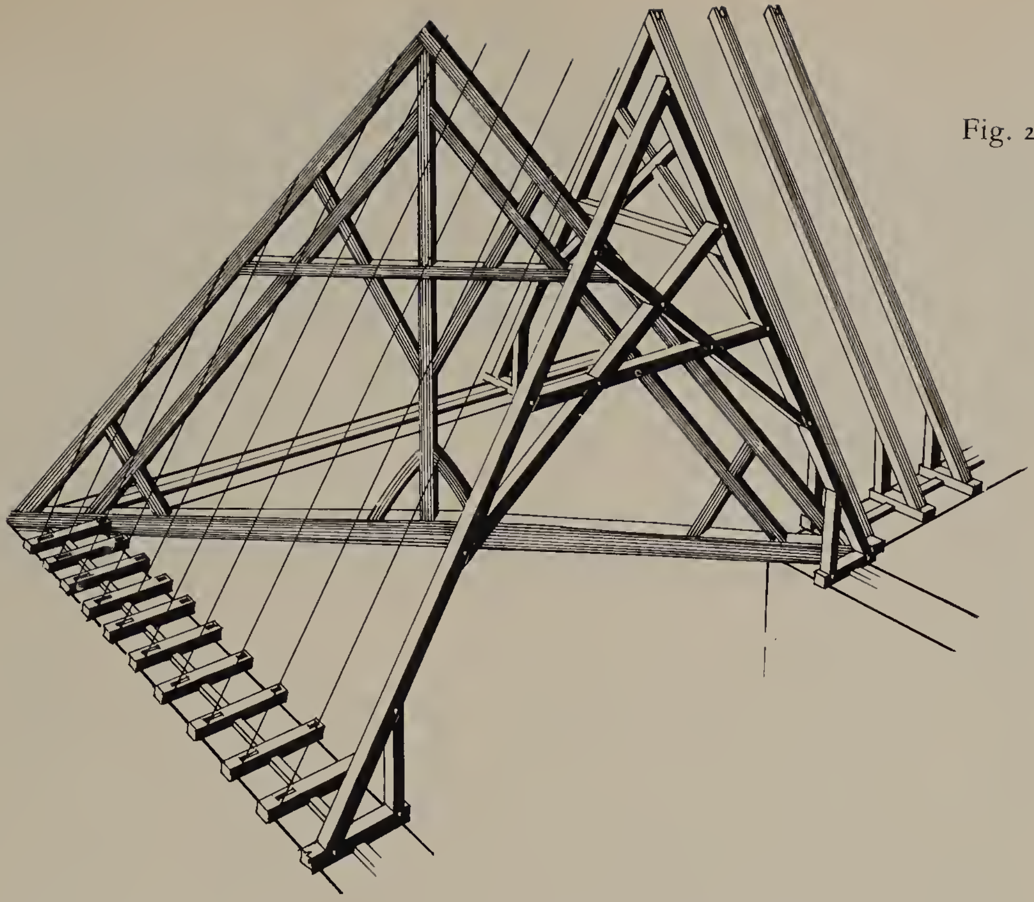


Fig. 20

trenched into the rafters' outer faces, and the apse roof was apparently single-framed and comprised twenty-seven couples that were scissor-braced and doubly collared. The scissors were "secretly" notch-lapped at their feet and barefaced-dovetailed at their tops, while the collars were tenoned. The apse itself was polygonal on plan and was fitted with a collar-king-post into which most of the radially disposed rafters were chase-tenoned at their tops, those not reaching the apex being diminished into the flanks of those that did and spiked. The scissor-braces at this point could not be made in one, since they had to tenon into both sides of the king-post or in most cases terminate at the king-post. Some braces were also chase-tenoned into the radial collars from above and beneath, in a manner similar to that described in respect of Salisbury. The "secret" notched laps were used for all of them. The four tie-beams had branching ends like those at Salisbury, and mounted posts—of which one is preserved in position—which passed the lower collars by means of secret notched laps at 90° and dovetailed into one side of the upper scissors; one such post is shown more clearly in Fig. 52. Parts of these posts were carefully chamfered into octagonal section, and it seems possible that there may have been some intention to combine them with some type of purlin—but no evidence survives for this.

The Angel Choir at Lincoln was built between the years 1256 and 1280 and still possesses its original high roof, in all probability completed by the same date, or a little earlier if time is allowed for the vaults to be turned under its cover. One bay of the roof is shown in Fig. 19. The de-

sign is unchanged from that of the roof over the nave east of the tower and has the slender, octagonally sectioned posts in similar positions, acting as direct vertical supports for the lowest collars—of which there are three in all. The open notched lap-joints were still used for the four collar-tying soulaces placed diagonally downward, while chase-tenons were used for the struts supporting the rafters above the lower collars. Long oaks for these rafters were evidently not available at this date since in this roof most rafters are scarfed, with the variation of the joint shown at the left of the illustration, this joint being supported by the collar struts. The great advance in this case appears to be the fitting of no less than *three* collar-purlins, each one trenched across its underside and housing the successive collars.

Scissor-braced roofing evidently continued in favour with some of those carpenters employed at this highest of levels, the cathedral, since the chapter-house vestibule at York Minister is so roofed. This roof may date from between *c.*1300 and *c.*1310—the last date being, I am given to understand, the most probable one for this work, the return of which is shown in Fig. 20.[18] The scissors in this roof were made in single lengths, since the roof-span was relatively narrow, and halved at all crossing-points such as at the collars; their terminal joints were chase-tenons as in the examples at Salisbury. The return, or angle, of this roof was effected in the interesting manner illustrated. The angle was first bisected by laying a tie-beam diagonally, and on this a king-post was set up and halved past the collar; this post was propped each side by applying secondary rafters as shown, and two raking-struts either side supported the rafters proper; the rafter descending on the inner turn of the angle was thus considered sufficiently stable to support the feet of all the "jacked" rafters which were pared off to fit its flanks and spiked in place. The method of wall-plating with a single small-sectioned timber laid along the centre-line of the masons' top course, and housed by each sole-piece, was one that continued in use in parish churches for a considerable time after this date in many counties of England.

At this point it is necessary to introduce a roof that has been variously dismissed hitherto as either of the fifteenth century, to which it was "conventional wisdom" to ascribe all carpentry of doubtful age at the opening of this century, or to the year 1816, when it was said to have been "renewed".[19] This is the nave roof of Oxford Cathedral (Fig. 21). It must be emphasised that this roof is very high above the floor and not clearly lit; consequently no examination of its component timbers has yet been possible, but if dated upon stylistic grounds and assessed with regard to the wealth and intellectual enlightenment of that city it is able to support

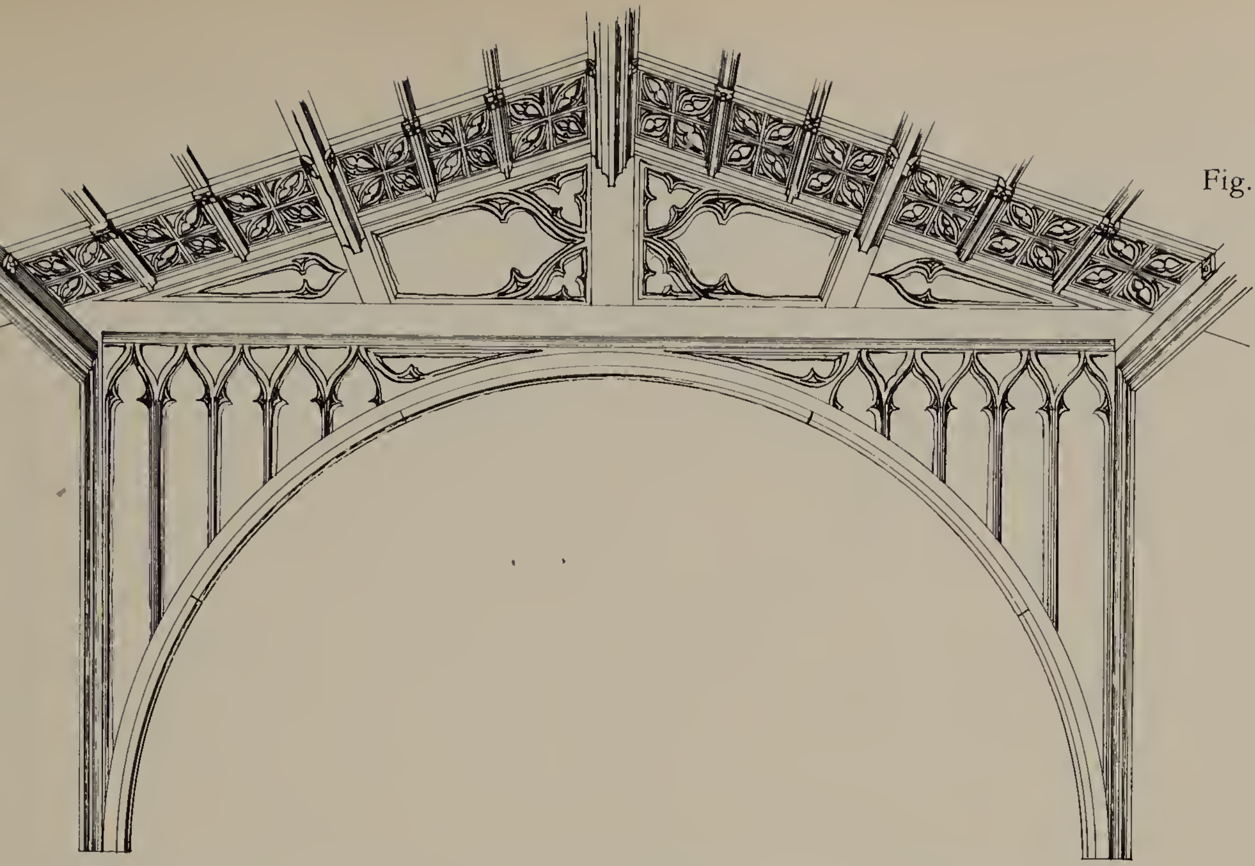
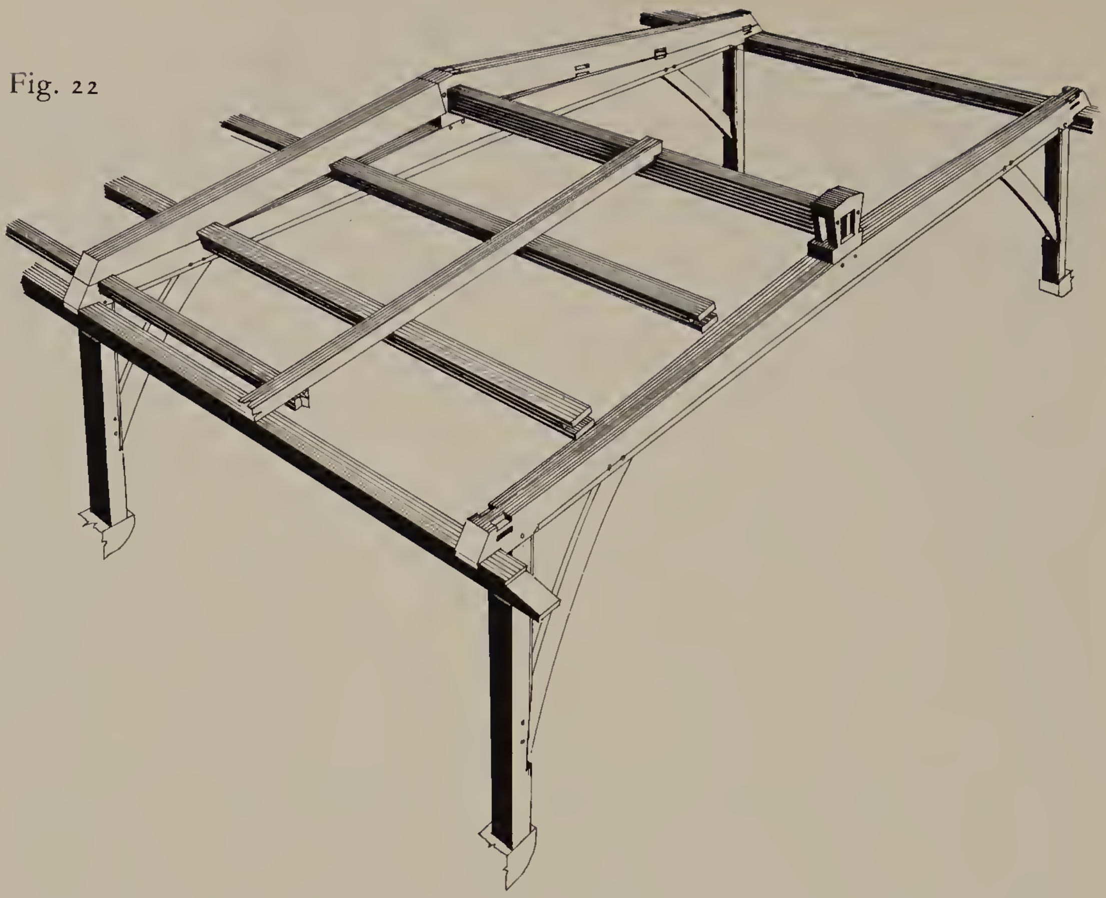


Fig. 21

an early date ascription—with which the patination of its timbers seems to agree. This roof, as shown, is of low and obtuse pitch, built on an arch of a single centre that is framed together out of five "compass" timbers; the spandrel-voids between this arch and the straight tie-beams are filled with tracery-timbers pierced with cusped lancets, five each side. The tie-beams mount short king-posts and raking-struts, which in turn mount a ridge-piece and side-purlins of heavy section—all worked with hollow mouldings and having fleurons, or human faces, either applied to the hollows or carved from the solid timber. The voids between the principal rafters and the posts and struts are, again, filled with wooden pierced tracery, in which trefoils predominate while the soffit of the whole assembly is treated as square panels each of which encloses four, radial cusped lancets—each bay of roof thereby showing ninety-six panels. If this renewal incorporates earlier timbers and is correct in principle, it should belong to the period of the choir vault, in stone, between *c.*1478 and *c.*1503.

A roof of similarly low pitch has survived at Bristol Cathedral, above the vaulting of the choir; this part of the building is ascribed to between *c.*1311 and *c.*1340 and attributed to an as yet unknown master of unparalleled genius. The roof is much patched and made good, but nevertheless enough survives to provide a sure basis for the drawing that is Fig. 22 and shows a single bay of length. In this work no joints are used that preclude such an early dating and, in terms of design, it is not merely the forerunner of the Perpendicular camber-beam roofs but a superior creation and one possessing many of the assets of the "built" beams that were to follow eventually, *after* the Perpendicular period. In this con-

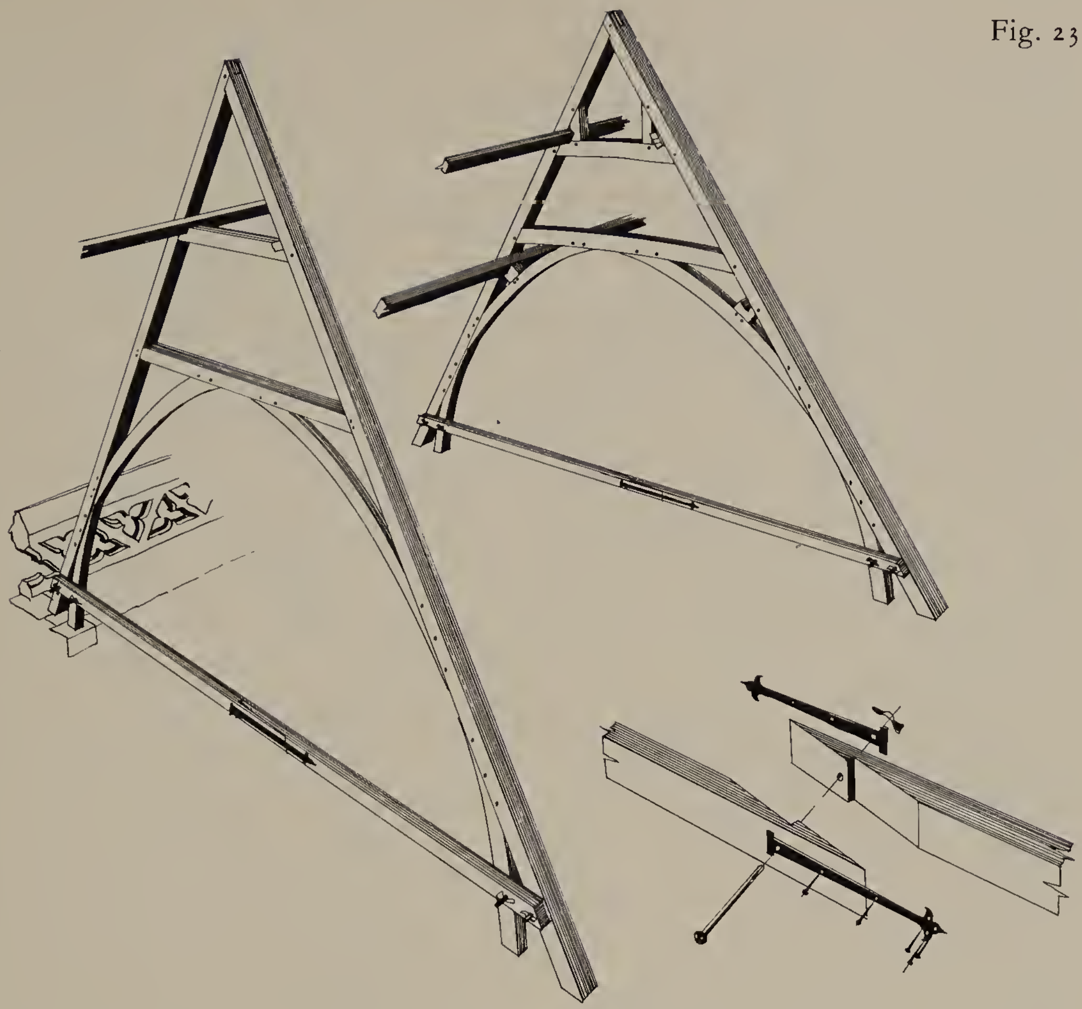
Fig. 22



text it should be noted that the lower of the two butted side-purlins is fitted by means of paired tenons, and since each of these tenons enters a different timber—the upper one enters the principal rafter and the lower the tie-beam—these two are locked together in a manner that inhibits their flexibility. This effect was sought, centuries later, by setting small blocks into trenches that were cut into the adjacent faces of built floor-joists. The dwarf king-"posts" set on these tie-beams have sunken faces to accommodate the massive ridge-pieces, and bearings with mortises above for the principal rafters; six common rafters were fitted per bay, and it did not prove possible to determine how these were jointed at their apexes. The date of this roof must also remain uncertain, until further information becomes available.

Returning for the next roof to Wells, where documentary information is more profuse, and also a little more specific, it is possible to study the differences between the first phase of building of the quire and the second, which extended eastward; both of these phases of building activity preceded the conversion of that cathedral's eaves to parapets, this conversion possibly having been complete by 1310.[20] One couple from each of these two "builds" is shown in Fig. 23, which drawing also shows the adaptation of their feet and the added, scarfed, tie-beams. The date of the existing quire roof is not known, but it is recorded that a tholus collapsed and fell on 21 December 1248.[21] This tholus may have been situated at the eastern end, and its fall might have occasioned the partial destruction

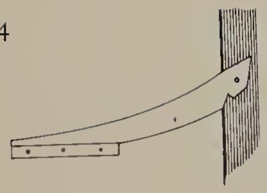
Fig. 23

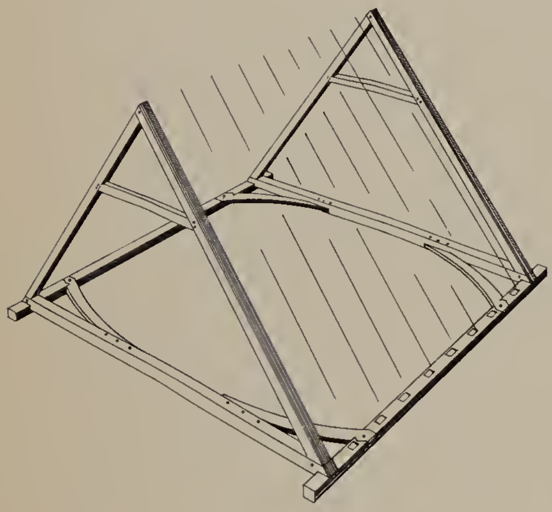


of the adjacent roof and subsequent re-roofing at that date; or alternatively, since both phases of roof over this quire pre-date the conversion to parapets which was probably complete by *c.*1310, we may assume either the building date for the whole quire, *c.*1175, which seems unlikely for a curved timber roof, or some re-roofing date between then and *c.*1310 which has escaped the records.

What can be seen, however, is that the carpenter responsible for the extension of this roof eastward saw fit to follow the design of the then existing roof, and also to supplement it. He added a pair of side-purlins lower down, and also a pair of struts on the high collar to retain the upper purlin more securely; and in addition to those features he introduced cambered collars at both levels—as shown, the earlier collars had been straight. This last fact may well indicate the beginning of the fashion which demanded, almost everywhere and for centuries, that horizontal timbers should be curved in order that they might not sag—or appear to sag. The conversion to parapet caused the sole-pieces and rafter feet to be sawn off, and it was felt to be necessary as a result to tie the principal couples together with beams. These tie-beams are shown in the drawing, as made, of two timbers scarfed at the centres with a "trait-de-Jupiter"

Fig. 24





joint which was augmented by strap-irons forged into fleur-de-lys terminations and affixed by forelocked bolts. It is important that the forelocks in this case were flattened on each side of the bolt to prevent their subsequent movement. This is also shown in the drawing.

The south quire transept at Wells has its vaulting roofed by a relatively small structure shown in Fig. 24. This transept was dedicated in 1330, and the roof must have been completed before that date. Comprising ten couples of collared rafters, with two tie-beams, it is nowise remarkable until the angle-braces in its corners are considered: these are nicely curved and tenoned into the beams, while their wall-plate ends fit into refined notched lap-joints, one of which is shown enlarged above the drawing. This fact indicates that these joints continued to be found the most appropriate in certain positions, and that those master-carpenters who still employed them were no longer affected by what had, apparently, been a transitory fashion for the "secret" form of the joint.

The Latin Chapel at Christ Church Cathedral, Oxford, possesses a high roof (Fig. 25) that was built originally in a vernacular style. The drawing shows one bay of this roof, which was tie-beamed and double-collared with two side-purlins each slope and wind-braces; the arcature of all these numerous braces is of the Decorated style. The Latin Chapel itself was, according to J. H. Harvey, built between *c.*1350 and *c.*1355, and to these dates the roof as it existed before it suffered numerous repairs would seem to belong.[22] The principal rafters are plate-yoked at their apexes, a device normally found restricted to the cruck carpenters, and these yokes are surmounted by a triangularly cross-sectioned ridge-piece—like the one recorded at the Siddington Barn in Gloucestershire, which is of earlier date.[23] The ridge-piece and side-purlins are scarfed with through-splayed joints as may be expected during the fourteenth century, and the roof is of great interest because, while it would have constituted "fine-quality" carpentry in a manor-house or a barn, is not of cathedral "style" and compares rather poorly with the better examples of that genre.

A high roof of great complexity is illustrated in Fig. 26, that surmounting the presbytery at Winchester Cathedral. This part of the building is dated to the period *c.*1315–60, and the architect is believed to have been Thomas of Witney, who died in 1342.[24] The actual timbers of the roof—as indeed is true of all the Winchester roofs—lack a patina such as is normally found upon ancient oak; but since something similar is noticeable in the high roofs at Wells there is a possibility of local atmospheric conditions affecting such timber in an unusual manner in both these areas of the country. This consideration apart, there are no structural or

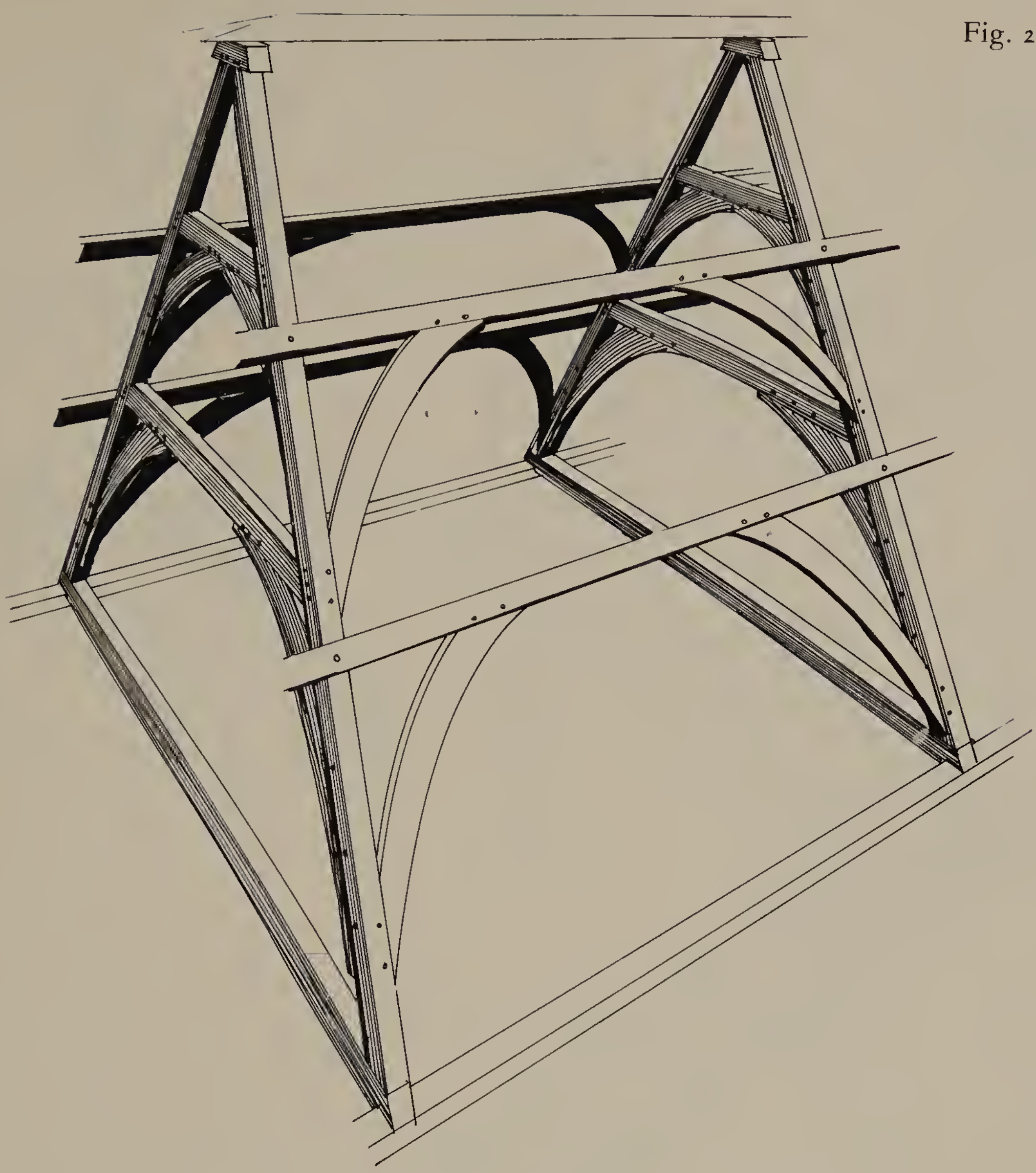
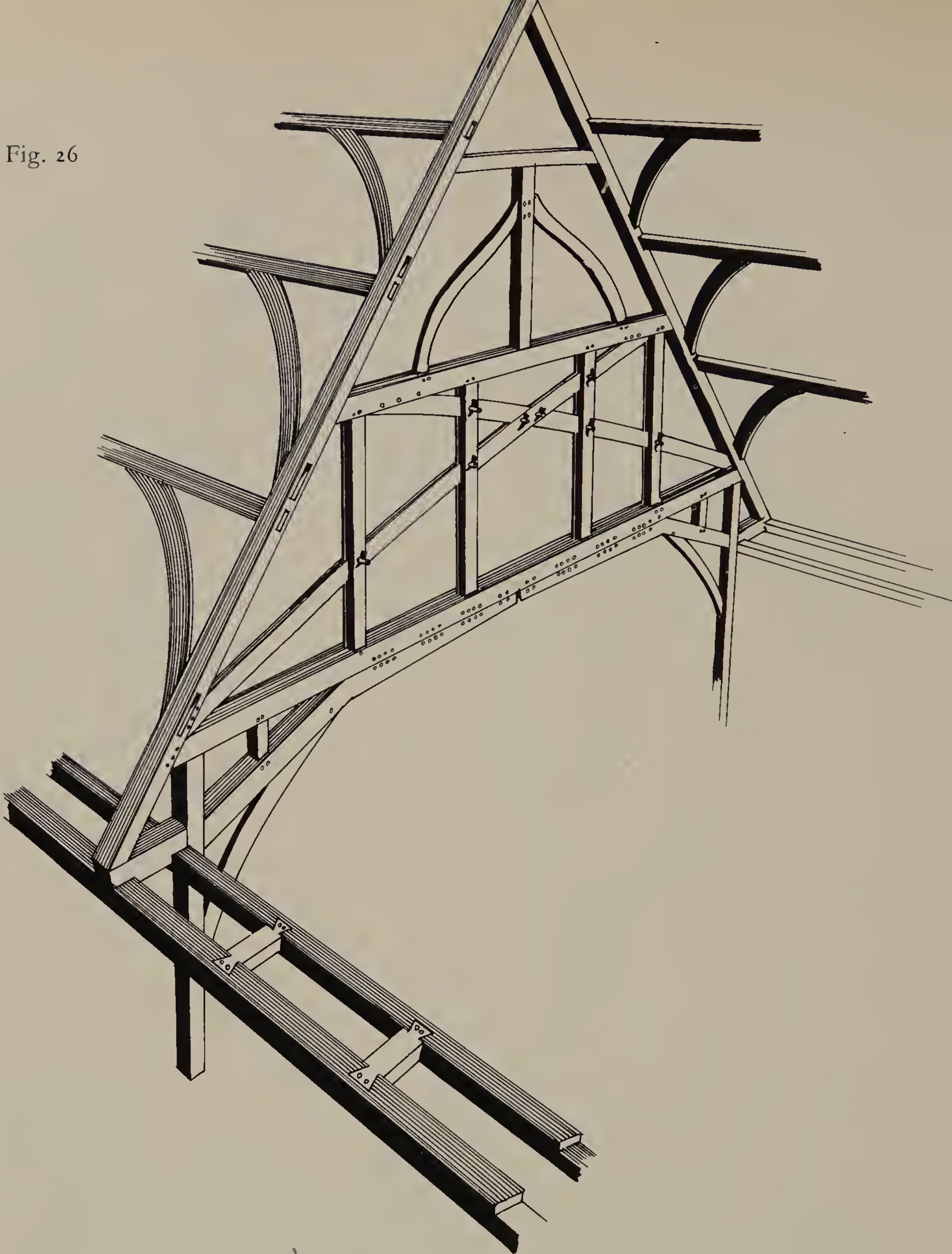


Fig. 25

technological reasons why this roof should not date from the time cited, since it is bolted entirely with forelock bolts. There is no structural connection between the wooden vault of this presbytery and the roof under discussion, but the roof appears to have been designed for such a vault since its alternating frames have posts which stand in the vault "pockets". The timber bosses beneath are ascribed to the time of Bishop Fox (1501–28) and the architect Thomas Berty.[25] Again, a carbon dating is necessary to clarify this matter, but the bosses are definitely added to an earlier vault.

The roof-frame shown in Fig. 27 is one of the few that is dated with some precision, to the years 1363–95, the episcopacy of Bishop Appleby, and the architect John Lewyn. It is the roof with timber ceiling of the choir at Carlisle, to which the arms of the subscribers were affixed.[26] This is a roof which must be among the finest of its type, built into a timber arch, that has survived. It is single-framed and double-collared, elabor-

Fig. 26



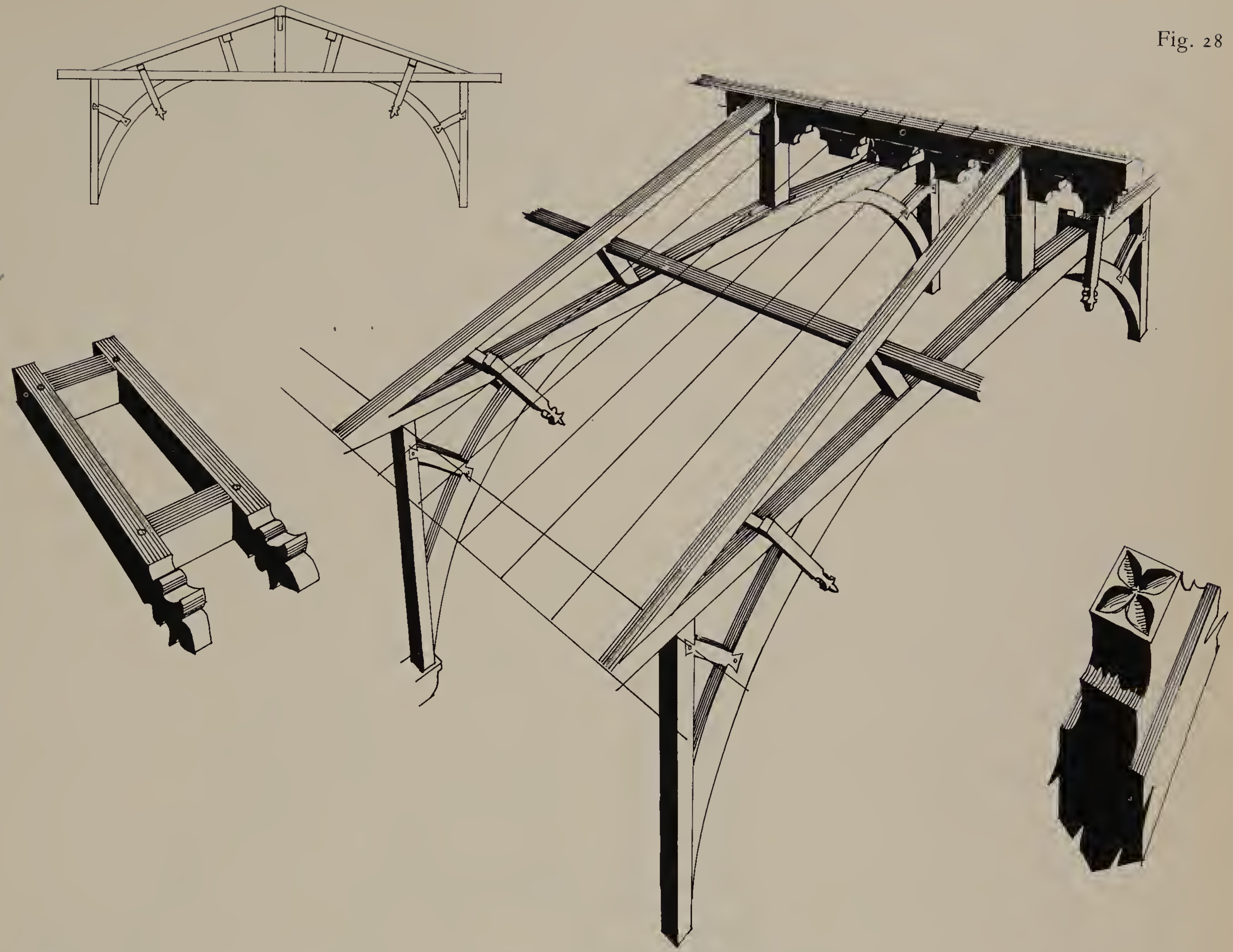
ately braced and strutted: it is perhaps a pity that the ceiling completely hides it.

The roof illustrated in Fig. 28 is nowise similar to the last mentioned one and is further, firm evidence for an advocation by some carpenters of the low-pitched roof; this example spans the Monks' Dormitory at Durham and was built between 1398 and 1404.[27] The arch-braces are clasped to their tie-beams with box-ties having fleur-de-lys terminations, and the ridge-piece is elaborately cusped—as shown. The span is very wide and the bays numerous and short, containing only five common rafters in each of the twenty-three bays.

Fig. 27

An entirely unrelated roof is shown in Fig. 29, which illustrates one of the short—four foot long—bays of the high roof above the lady chapel

Fig. 28



at Hereford Cathedral. This chapel was probably built between 1217 and 1225 inclusive,[28] and the roof itself appears to be unrecorded but for the restoration by James Wyatt between 1786 and 1796. As may be seen, this roof was a development of the scissor-braced type, in which the principal rafters actually stand upon the scissors' backs—a technique later exploited by Wren. Six side-purlins were fitted and a ridge-piece diagonally set, while the sole-pieces are much elongated. During the restoration cited the pitch of this assembly was raised with oaken framing, and its sectional view today is shown inset.

The next roof, that of the north-west transept at Canterbury Cathedral, is the only surviving medieval roof there; it is illustrated in Fig. 30. The transept itself was designed by Richard Beke and built during the period 1448–55.[29] It is a fine roof exceedingly well wrought, with an elaborate variety of bracings—including "scissored scissors"—and double, wind-

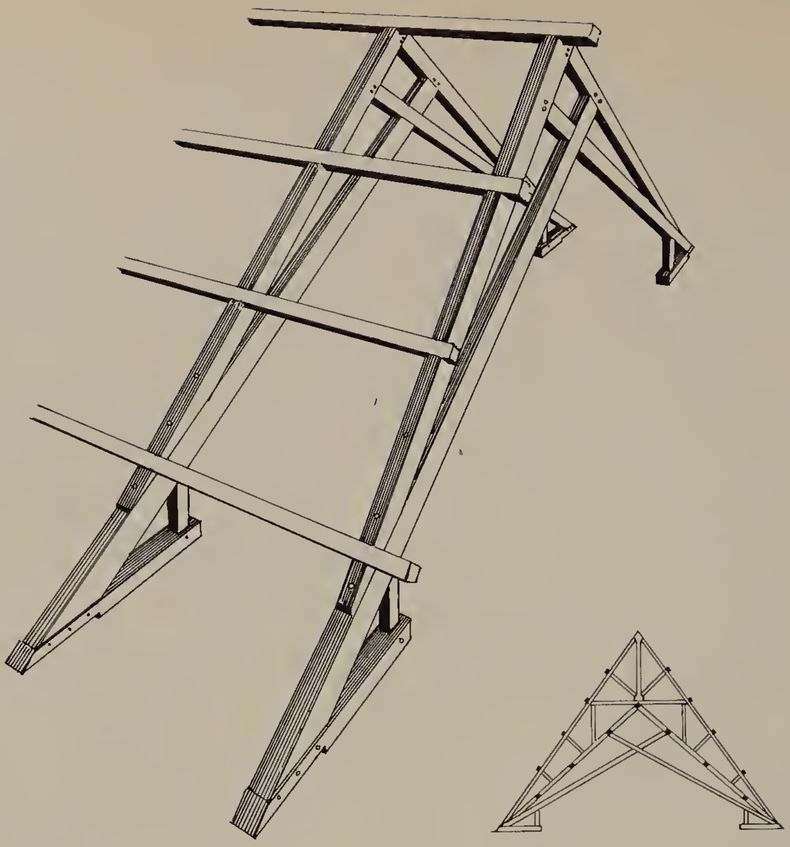


Fig. 29

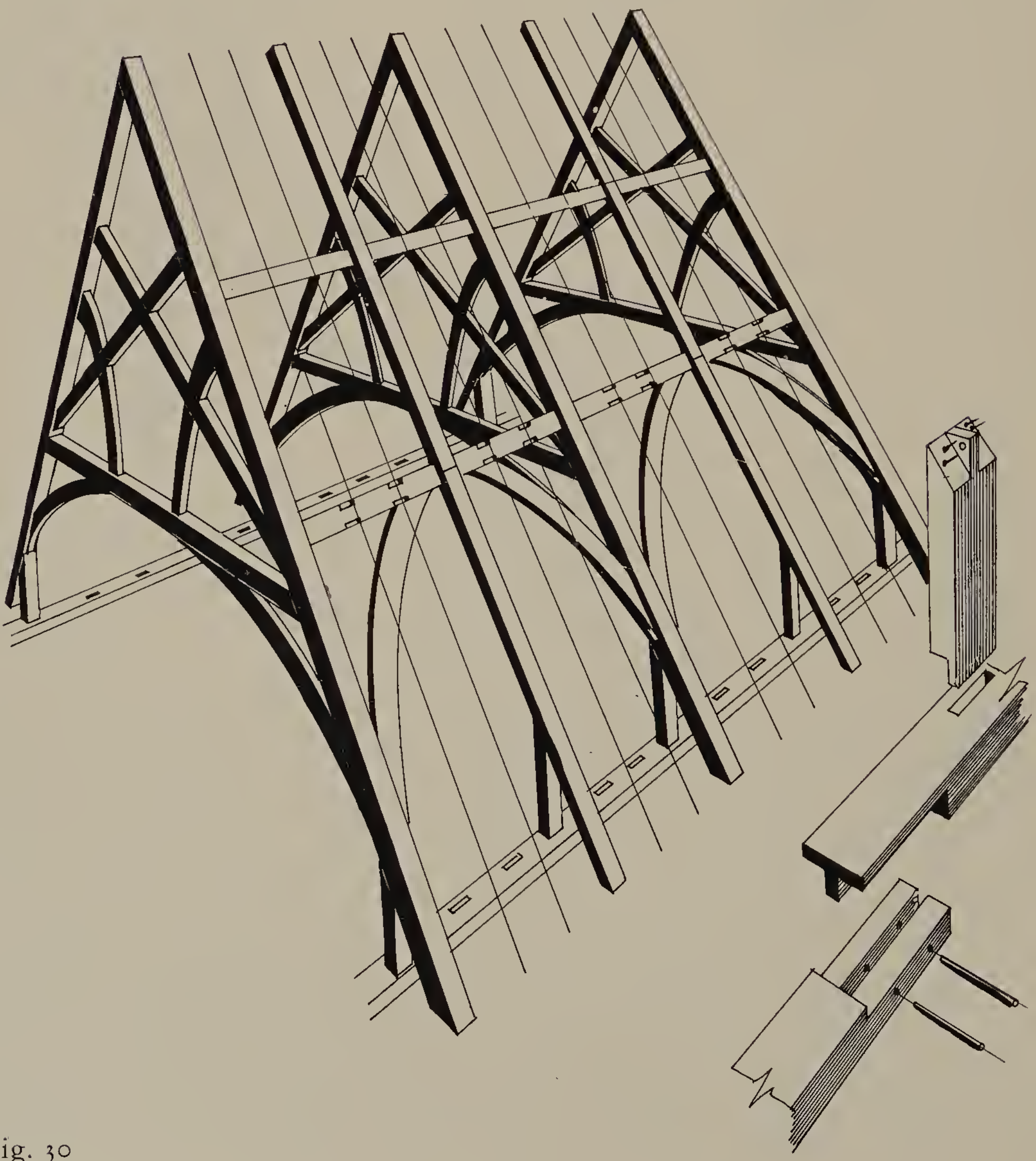


Fig. 30

braced side-purlins. The scarf-joint used for its inner wall-plates is of the type recorded for the monastic barn at Little Wymondley in Hertfordshire which has been carbon dated by Professors Horn and Berger.[30]

The roof to the cloister at Hereford is illustrated in Fig. 31. This is king-post with ridge-piece and side-purlins, the last named being housed in remarkably deep principal rafters. The whole is carved in relatively deep relief, as shown, and the tie-beams are arcaded; the styling of these timbers and the profile of the mouldings is of an "assured" Perpendicular character—the moulding-profiles are deliberately accentuated in the drawing. The top-plate scarfs, one example of which is shown, are of the edge-halved and bridle-butted variety that absolutely characterises this period. Whilst the precise date of this roof is not known, the east walk of the cloister was designed by Thomas Denyar (1406–16) and was built between 1412 and 1418.[31]

The bay of roof shown next (Fig. 32) is one from the extremely important roof of King's College Chapel, Cambridge, from whence it could equally well be from the first phase of building or the second major one since the visual appearance of the frames is in both cases identical. This fact is, as will be explained, highly misleading, and the break in building at Cambridge tells us more concerning advances in technology than most similar breaks (as at Lincoln Greyfriars or the Wells quire), and I

Fig. 31

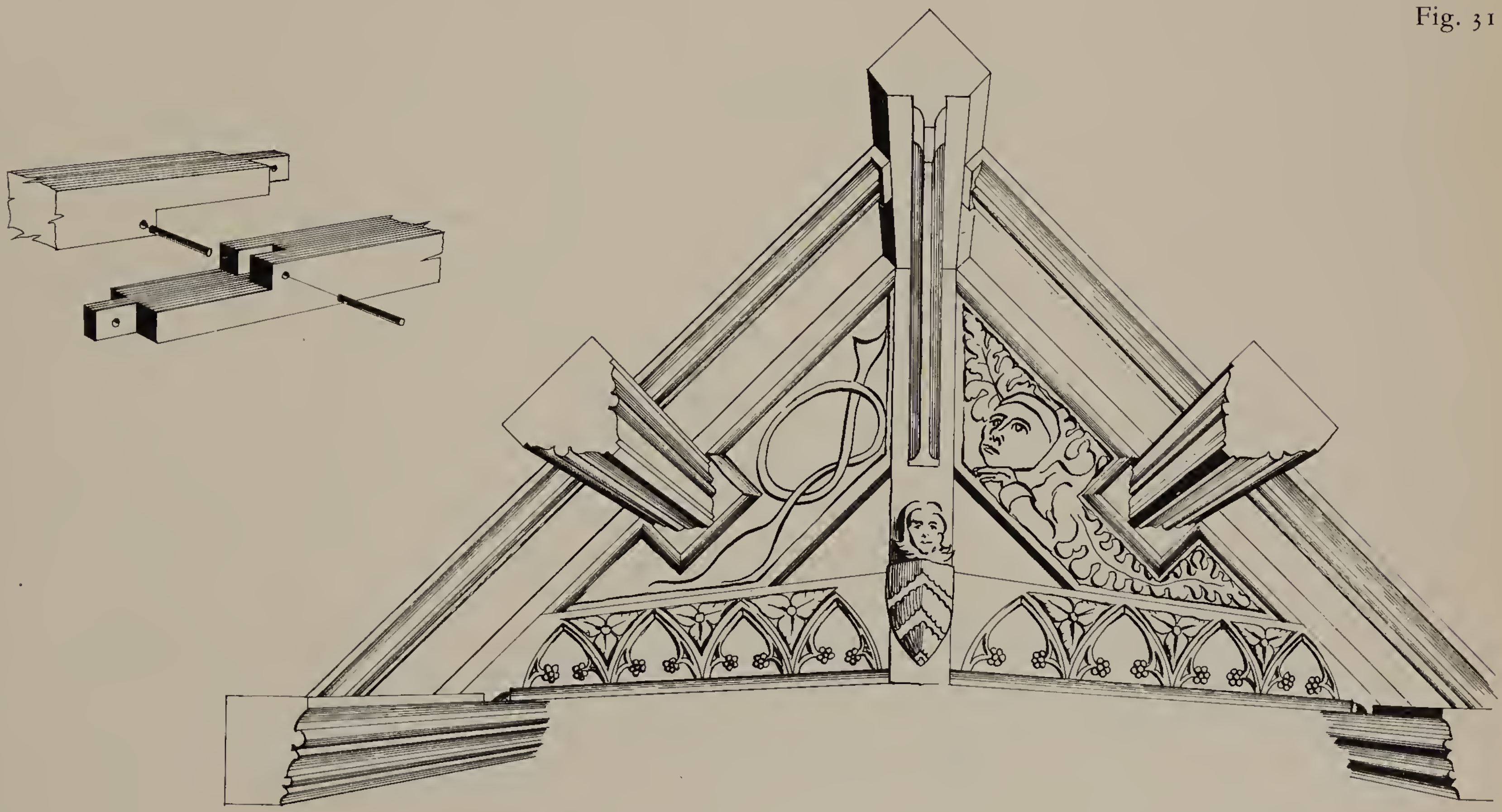
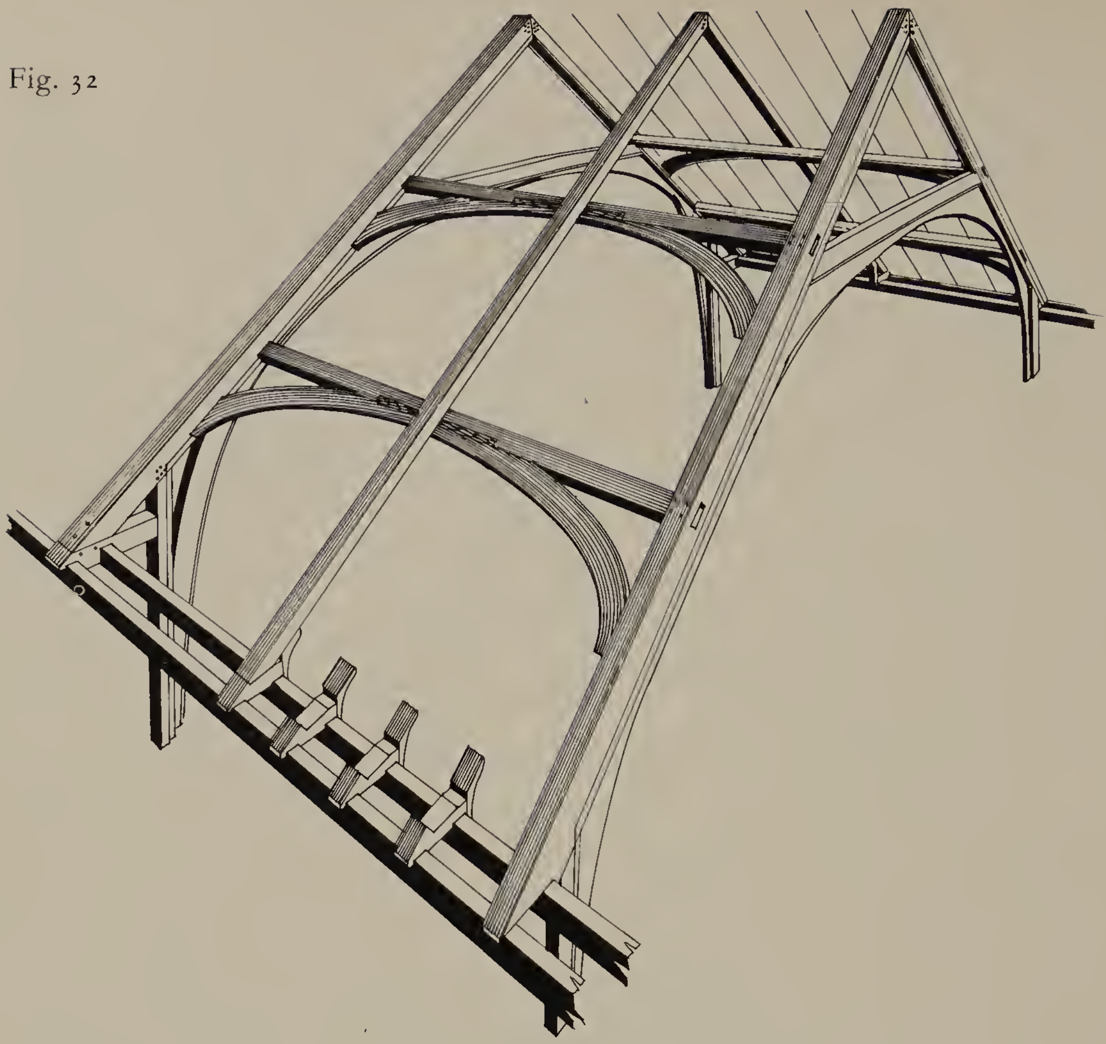


Fig. 32



shall therefore dilate upon it. As shown, this roof is wall-pieced and arched to collars throughout its great length; it has two side-purlins in each slope with wind-braces beneath them—all of flattened and late Perpendicular arcature. The sole-pieces used are unusual, as shown in the drawing, and they relate visually to others that are ancient. As was the case at Wells, the supreme importance of the carpentry is equalled by the accuracy of the documentation, and we know that no part of the main roof dates from the first period of building in 1446–61;[32] but by the end of the second phase covering the years 1476–85 the five eastern bays had been roofed, by one Martin Prentice. In fact, we know that either during or a little before April 1480 a skin of parchment was bought on which Martin Prentice was to draw the roof-design. The roof as then built looked as shown in Fig. 32, but the jointing of its side-purlins into the principal rafters was effected as shown at *A* to the right of the Fig. 33—that is, with masons'-mitres worked on the rafters and central tenons, unrefined, on the purlins. According to the investigations of my informant, the framing of the remaining and greater part of this roof was resumed in March or April 1510; there were various delays; but the work was ultimately completed in the middle of August 1512—trusses were then ready. At about the same time, mid-August, erection of the roof

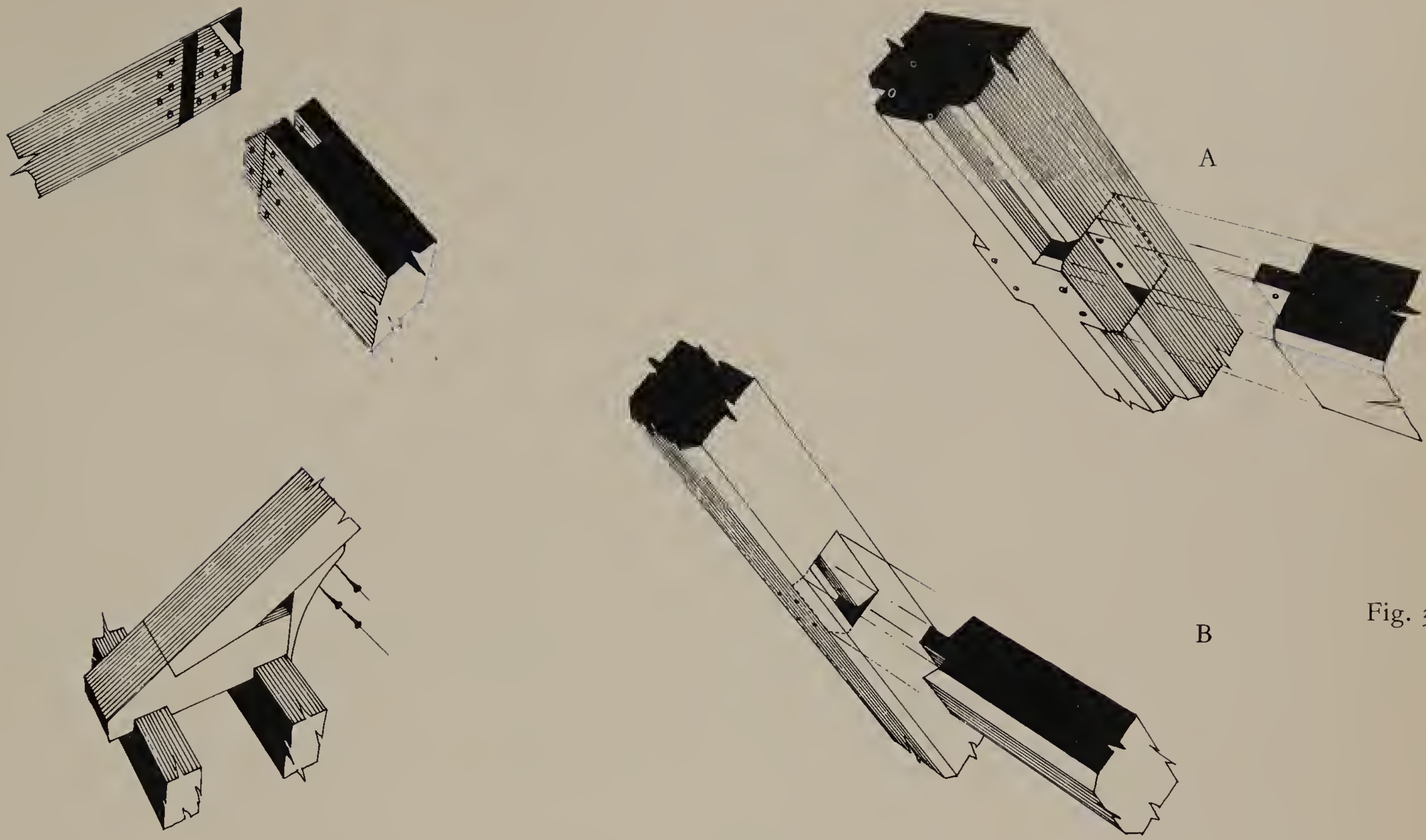


Fig. 33

began, and also apparently its leading by the plumbers, and it seems to have been finished by the middle of September 1512. It is also known absolutely, in this case, that the carpenters *thereafter* began to prepare the scaffolding and centres for the vaulting operation. What had occurred during the period of the interruption was the invention, apparently, of the tenon with diminished haunch—a refined and much stronger joint. This new technique was immediately employed, for—as shown at *B* in the drawing—tenons with such haunches were used for all the purlins of the remainder of the roof. They were also given "spurs" instead of the ancient masons'-mitres to enable them to meet the rafters' chamfered edges. The master-carpenter responsible at King's College Chapel at the time (1509–15) was Richard Russell, who from 1490 had been in charge of the carpentry of Westminster Abbey, later worked on the timberwork of St. Margaret's, Westminster, and afterwards on Wolsey's works at York Place (Westminster) and Hampton Court. Russell died on 14 May 1517. This, then, gives us one more precision-dating instrument since we can by this information avoid ascribing any structure with haunched tenons to an earlier date.

This last point is illustrated by the next example (Fig. 34), which is one bay of the nave roof at Bath Abbey. This was an open timber roof of

elaborate design and construction, approximating to a single hammer-beamed design. The common rafters, where they tenon into its ridge-piece, are fitted by means of diminished-haunch tenons, probably indicating that the present cathedral was not roofed until toward the end of its building period, 1501–39.[33] A section of this ridge-piece is shown in the illustration, with two of the tenons involved. It is very noticeable that this roof, which must apparently be attributed to the brothers Robert and William Vertue, was of the low-pitched type of which some earlier examples have been given.

The nave roof of Tewkesbury Abbey, although not original, is of considerable interest since it appears to relate closely to a famous work by Wren (in St. Paul's Cathedral). This is shown as a single truss in Fig. 35. It is of the low-pitched type, framed in well-finished oak, and the least possible use of iron was made by its architect. It is a king-post roof with two raking-struts each side, a ridge-piece, and one side-purlin each slope; the purlins are fitted by means of diminished-haunch tenons into the principals. An important feature is the use of trussed frames, with common purlins, instead of the preceding practice of common rafters. This was a development that rapidly became invariable in New England where domestic roofs were so constructed by the time of the third generation of settlers there. The feet of the king-posts at Tewkesbury are curiously jointed to the tie-beams by means of central tenons that are

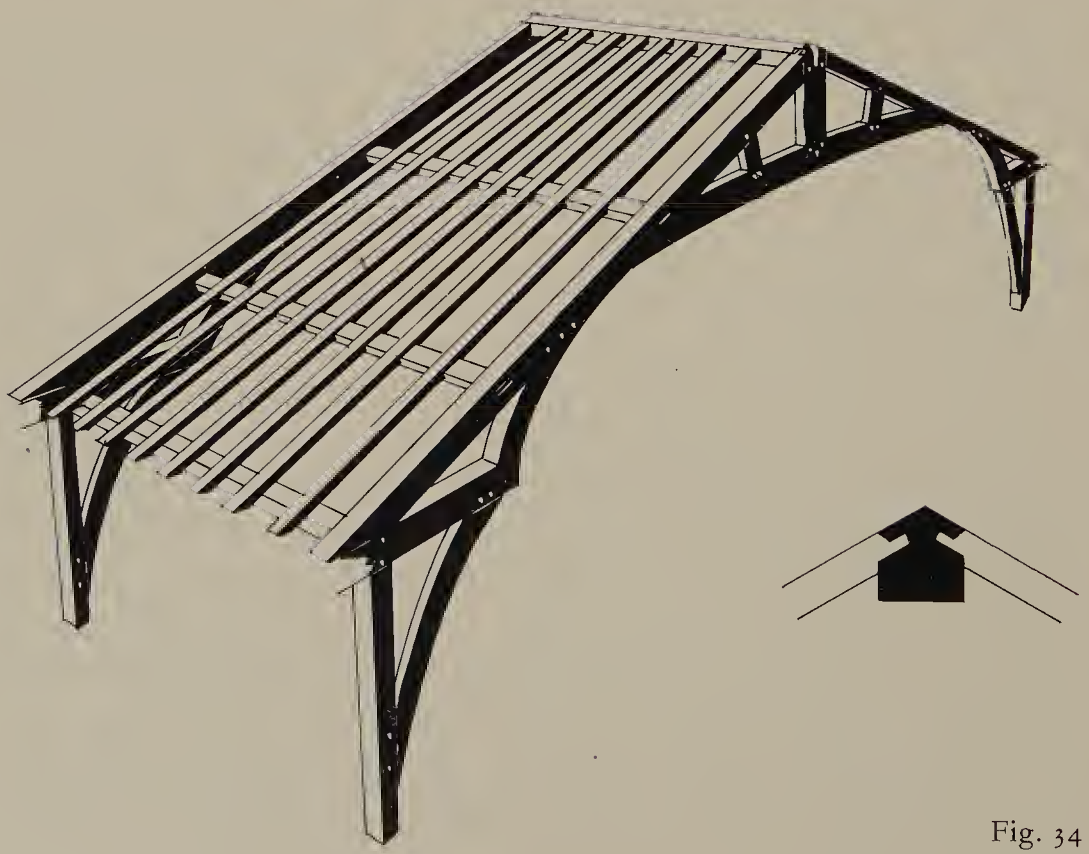


Fig. 34

wedged tight, pegged three times through their faces and finally forelock-bolted. A date earlier than *c.*1700 is strongly suggested by these details, since Wren specified threaded bolts for St Paul's in 1710.

The nave roof of St Paul's is shown in Fig. 36, designed relatively traditionally for its type by Sir Christopher Wren and the building completed between the years 1675 and 1710 inclusive. This is a king-post roof trussed with pendant king-posts, as in the preceding example, with raking-struts and common purlins to bear the cladding. The jointing is shown at the rafters' feet, where it is unusual and is a form of bridle-joint; at lower left are the wall-plate scarf, which is the medieval ground-sill type of that joint, and the lap-dovetail used to seat the tie-beams. The new introduction here seems to have been the strap-irons used at the king-posts' feet and at the rafters' eaves triangles, where in both cases threaded bolts with nuts were used. The span is a little over fifty feet, and Wren evidently had some difficulty at that late date in English history to obtain the fifty "great oaks" necessary for the provision of these extremely long, and un-scarfed, tie-beams. It is published that the quest for these trees absorbed some years, and that they were eventually supplied by the Duke of Newcastle in 1693 but not delivered on site until 1696.[34]

A roof built much later, but necessarily to a steep and medieval pitch, was that designed by L. Tebb between *c.*1770 and 1780 to span and clear

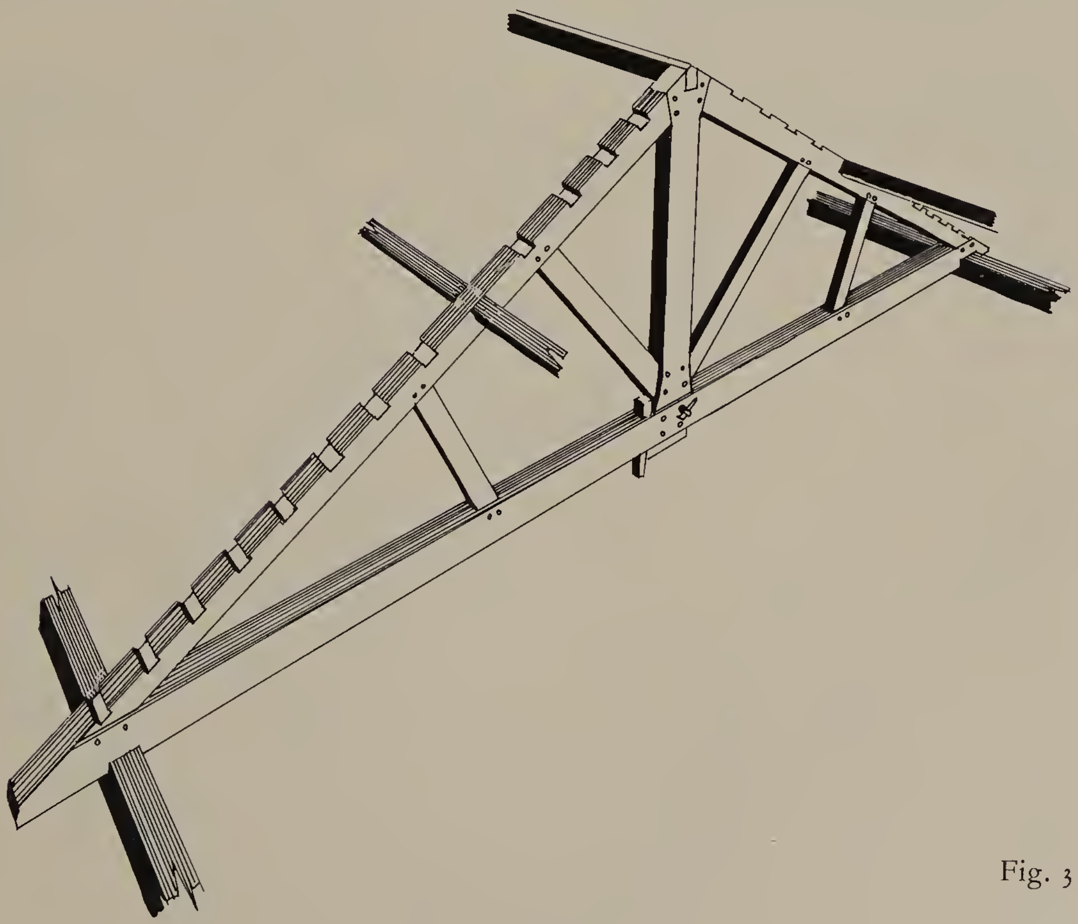


Fig. 35

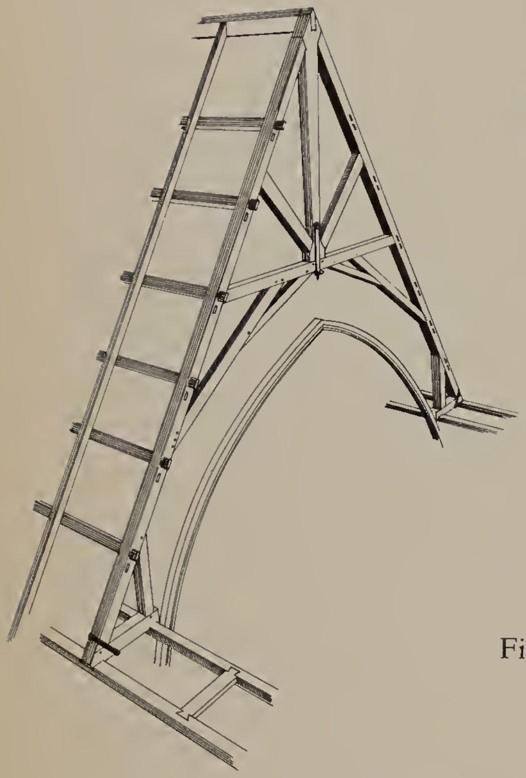


Fig. 37

the ridge of the timber vaulting in the south main transept of York Minster.[35] One frame of this roof is shown in Fig. 37, together with a section of the timber vault-ribs, which are of late medieval date. The design is excellent, being a roof of eight cants below its collars and a king-post with raking-struts above them. The whole is eclectic inasmuch as common purlins are combined with common rafters, the former being tusk-tenoned through the principal rafters—as shown in the drawing. Iron strap-work was applied at the normal points, king-post feet and eaves triangles. This roof had begun to spread, however, by *c.*1870, when it was reinforced with clasping scissor-braces set on each flank of these trusses by G. E. Street.[36]

Fig. 38 is of the high roof of the choir at York which is datable to the restoration of 1829–42 by Sir Robert Smirke. It is a good roof spoiled by very dark creosote which, in addition to the poor light above the vaults, makes it difficult to perceive in detail. The cast-iron shoes in which its tie-beams are located were cast by "Harwood & Dalk"—York, 1829, as the foundry-marks testify on their flanks. The truss design is elaborate and is basically queen-post; to this is added clasping king-posts

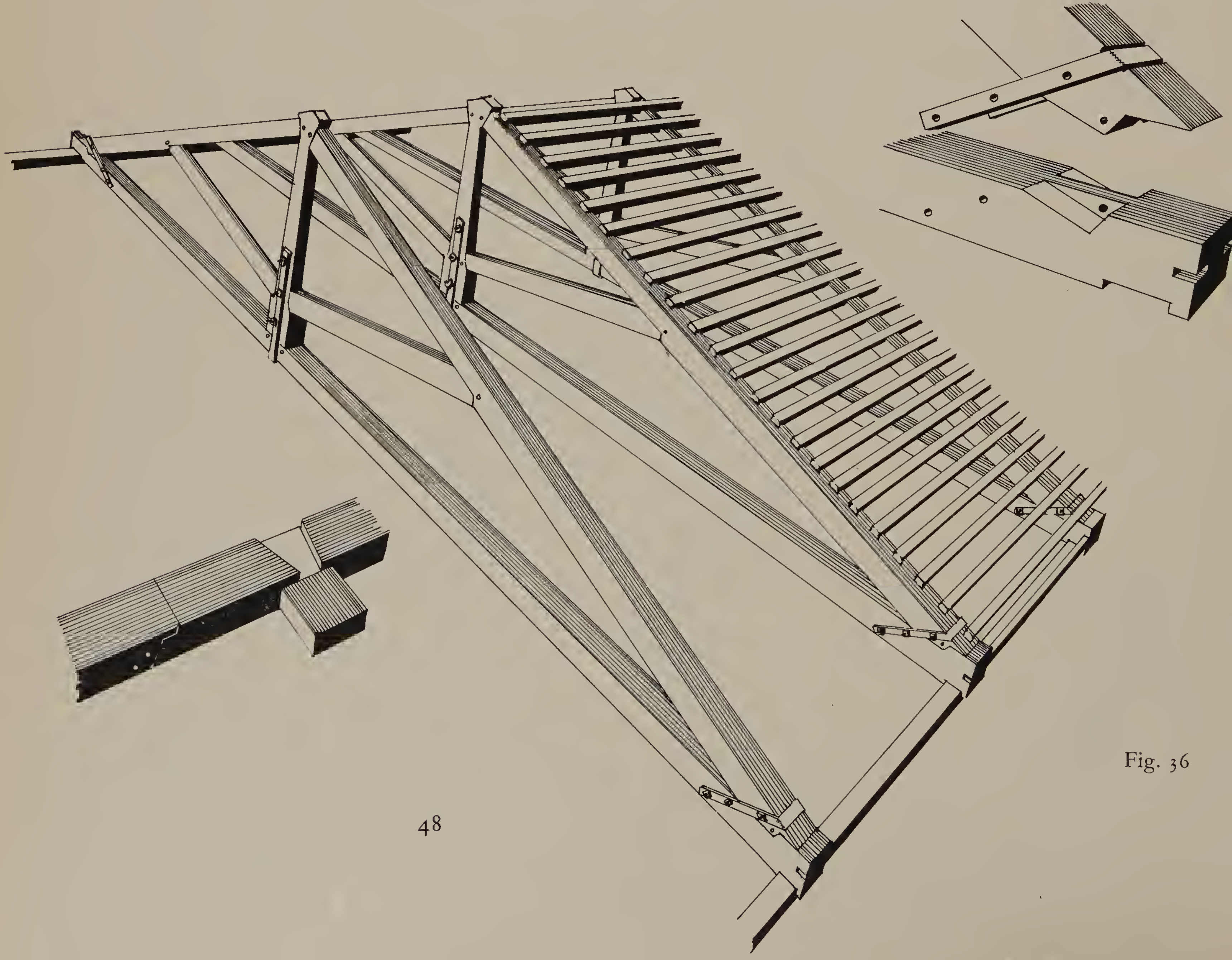


Fig. 36

and clasping struts, adequately strap-ironed and bolted; eleven common purlins are set on each slope and the slopes are saltire-braced, in-plane. Both oak and pine were used in this roof, the very long tie-beams being of the former. A similarly ambitious roof is shown in Fig. 39, the high roof of the northern great transept at Rochester Cathedral. This roof results from the restoration by L. S. Cottingham in 1825, when the three eastern arms had their high roofs put back to what had been their medieval pitches, indicated by the flashings on the crossing tower. It is almost entirely of softwood but most intricately framed, having a pendant king-post and raking-struts above the collars, which form the top of the incredibly complex systems which surmount the "built" tie-beams. A close study was evidently made by Cottingham of the possibilities of softwood carpentry, and this resultant roof-truss design must be com-

Fig. 38

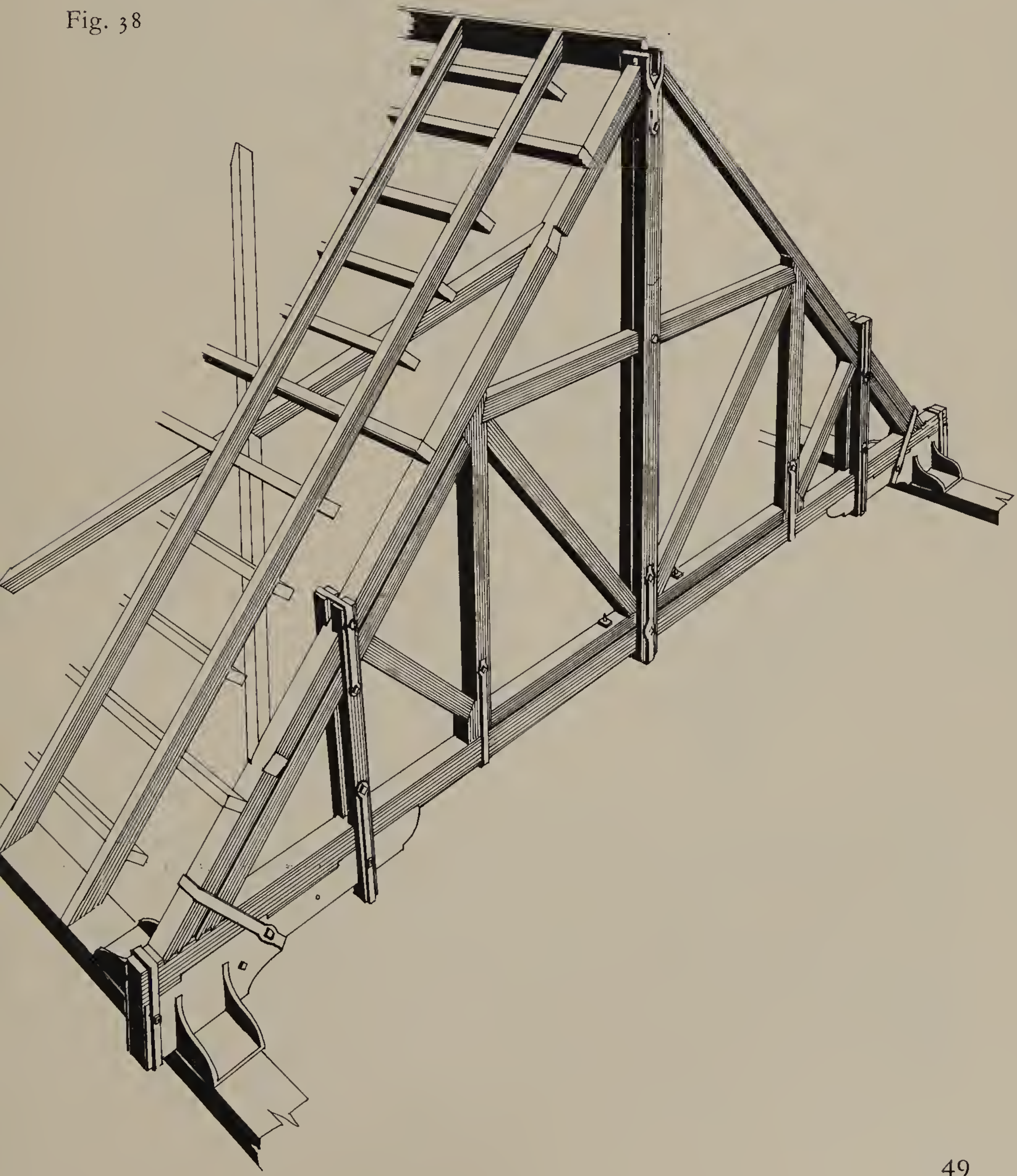
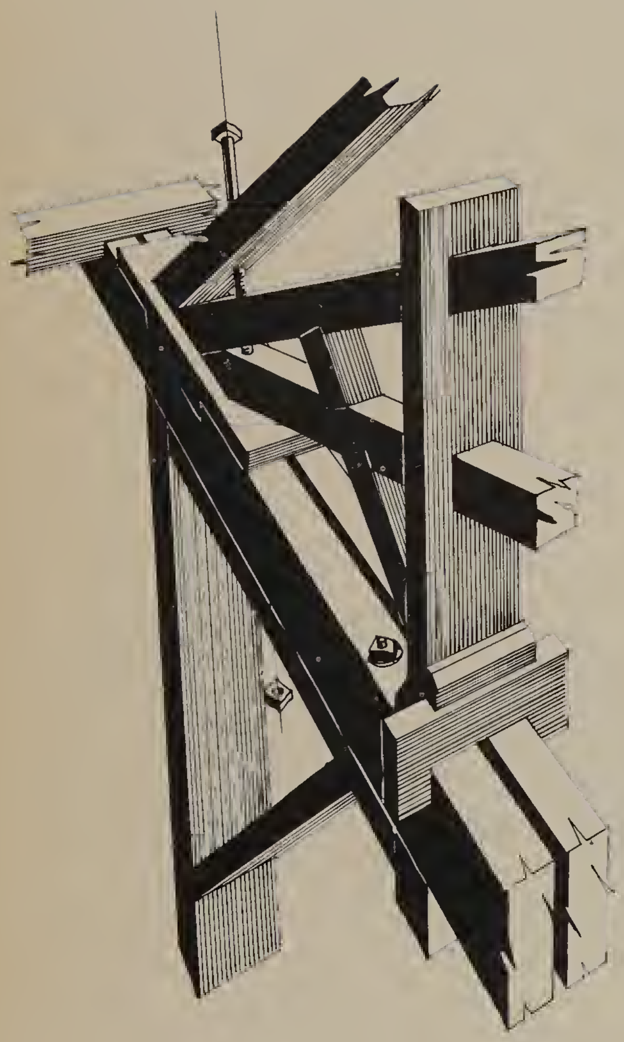
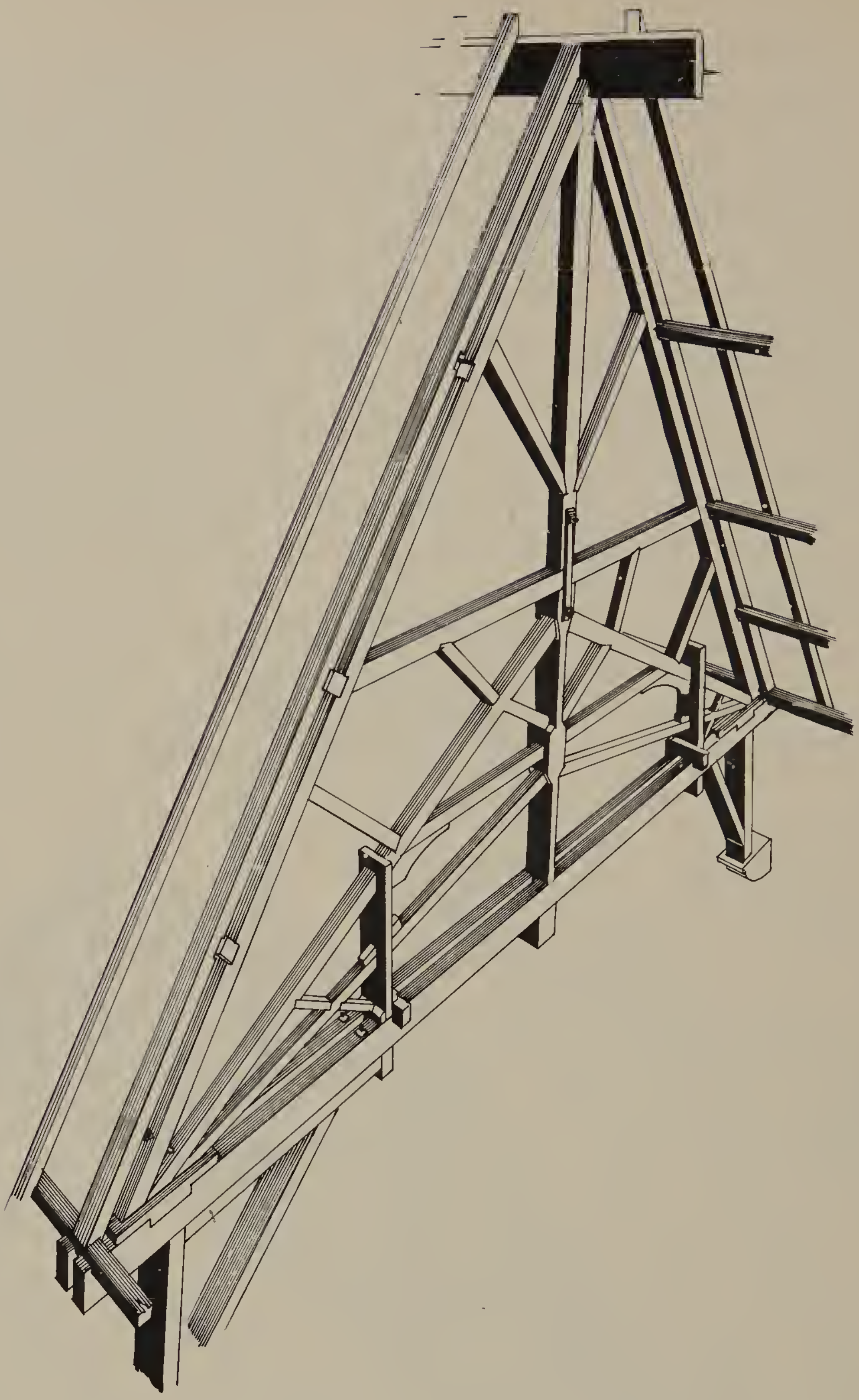


Fig. 39





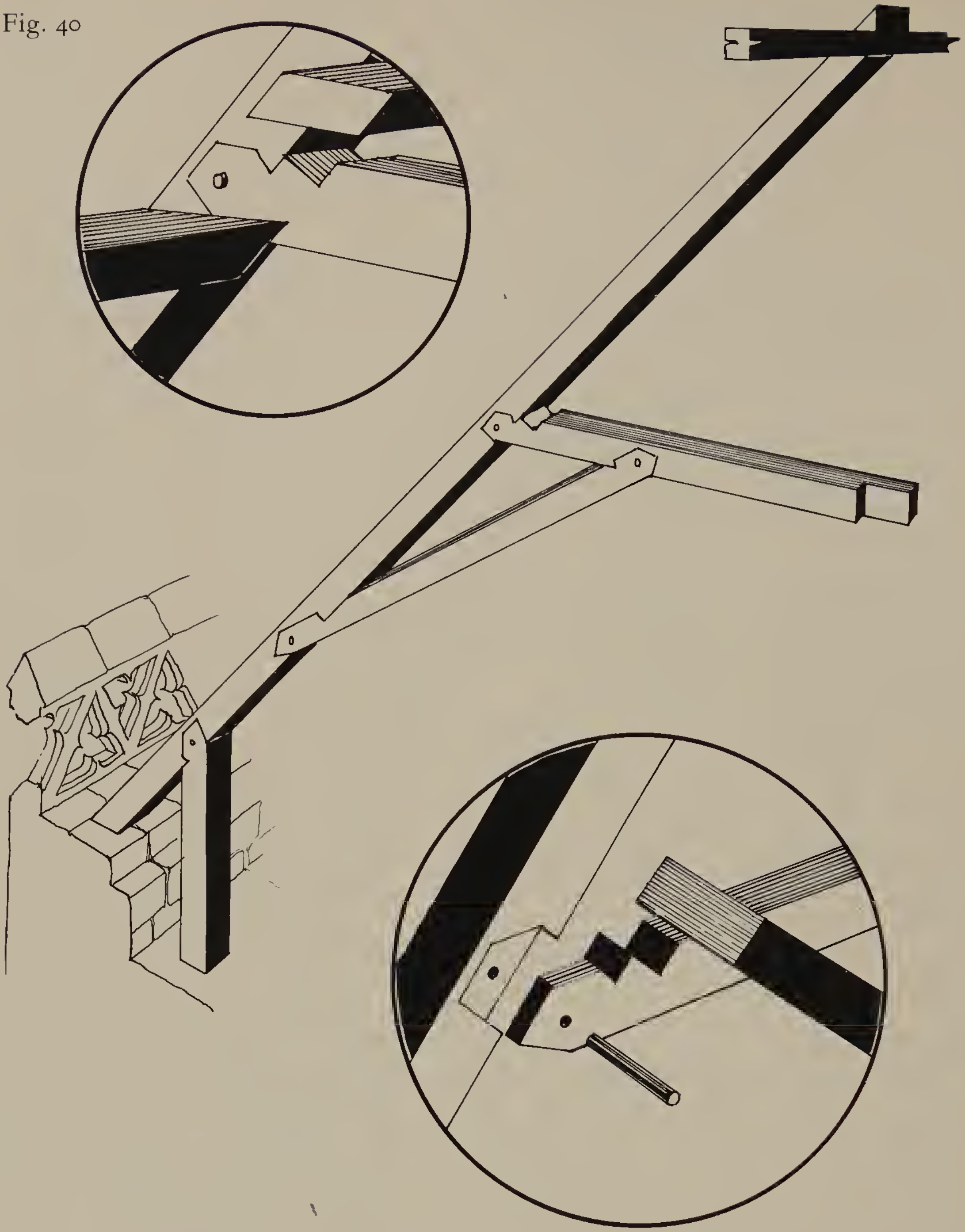
mended; the complex below the collars forms, in a single unit of framing, a sagging-truss for the tie-beam and compressive raking-strut mountings for the superimposed principal-rafter triangle. The whole is, in addition, set upon brackets which stand upon stone corbels of uncertain age—possibly pertaining to the earliest roof-design for this transept.

2 LEAN-TO ROOFING

The examples of lean-to roofing that have survived from the medieval period are, perhaps, rather less in significance than those of ridged main-span roofing; and the earliest among these is that of the northern triforium aisle at Wells. This roof is as closely datable, to the "break", as is the main-span roof of the nave already described, since the same change of jointing with continuity of frame-design can be seen in this case. The actual date of the lean-to roof is probably an earlier one, since a triforium might well have been worth roofing long before the walls had attained their ultimate height—the eaves above the clerestory. One principal rafter of this is shown in Fig. 40. This design is well in accord with the principles of the possibly later nave-roof, but on close analysis different. It has single collars that bear side-purlins, timbers which in this situation can only serve to keep the common rafters in a continuous plane, since the "racking" of such a roof which leans on two fixed and stable plates is impossible without the inclination of the masonry carcase. It is therefore a double-framed roof that owes its invention to an entirely different motive than does double-framing in ridged roofs. A conversion of the lean-to roofs at Wells from eaves into parapets was also effected, with the same result that no base-triangulation or wall-plating of the first "build" has survived for study, although the ashlar-pieces have frequently been left in position. There do not seem to have been any triforium tie-beams, but this is nowise certain. The span from the outer face of the triforium masonry to the inner faces of the ashlars is in the northern quire triforium sixteen feet—quite considerable—and it is a little surprising, perhaps, that this is not more literally half a main-span roof having two collars and tie-beams at its critical points.

The next example may be the roof of the north choir triforium at Lincoln, a frame of which is illustrated in Fig. 41. This is a very graceful roof in which restrained curvature of timbers and relatively slender cross-sections combine into a most pleasing appearance; perhaps because of its deliberately light-weight construction it was designed to exert its weight and thrust, untied except by its eaves, directly against the masonry. The notched lap-joint is nowhere used in this work, and since it evidently continued to be used at Lincoln until the time of the Angel Choir main-span roof we can assume that this example is not the first roof

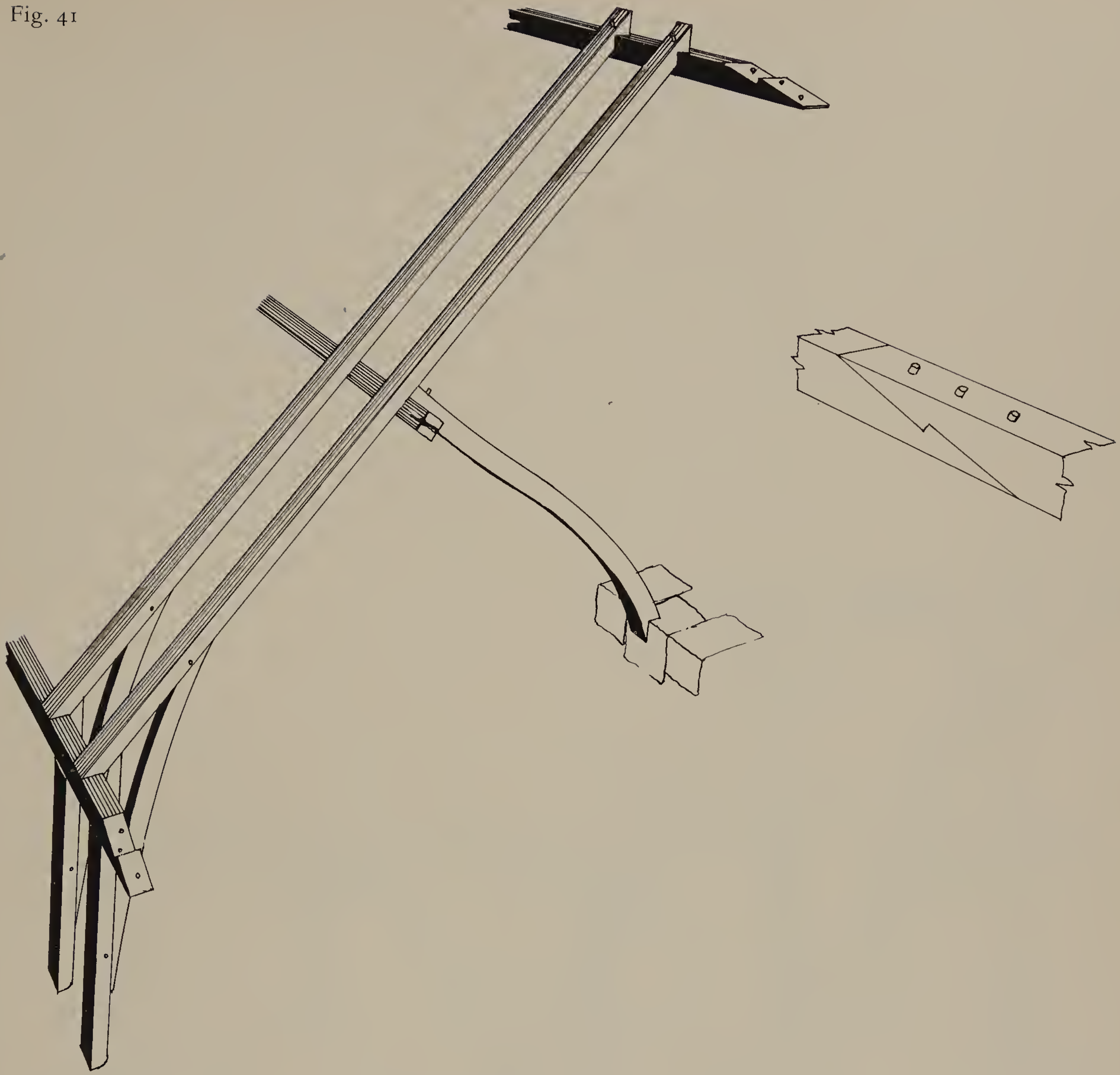
Fig. 40



in the position concerned. The choir and east transept were completed between 1192–1200, under Geoffrey de Noyers and Richard Mason,[37] but for the roofing of this part at some later date there seems no evidence other than that of its different structural method. Its eaves are triangulated in the least effectual manner which, if considered with the provision of the purlin and its sinuous strut, bird's-mouthed over the masonry, indicates that it was thought necessary to prevent its plane from sagging —and no more. Its survival until today in tolerably good order seems to show that this provision was, indeed, adequate.

The most splendid surviving lean-to roof in any English cathedral is that of the northern triforium of Salisbury. Fig. 42 shows two closely set

Fig. 41



frames of this from the choir, which can be dated between 1225 and 1237,[38] and attributed in general to the architects Elias of Dereham and Nicholas of Ely. This is a most elaborate essay in timber, and one in which provision was made, at the tops of the posts carrying the top-plate, to prevent "racking". In fact, it is an approach to an irregularly and lean-to sectioned timber-building that could be permanent on the ground; whilst tailor-made for its triforium situation, it is not dependent on that situation for anything other than its invention. The posts themselves have their feet triangulated on sole-plates, the frames are secondarily raftered, the raking-struts transmit any tendency to sag into a thrust that is diverted down to the sole-plates, and two side-purlins are fitted into

the slope. The top-plate is set into the normal stone "hooks" and the clear span is, in the choir triforium, fourteen feet. The triforium itself is adequately supported by masonry, there being asymmetrical arches in the form of flying buttresses that occupy the spaces between the close-set timber frames of the roof. The turning of the corners at intersections of transepts with the Cathedral's major axis is even more elaborate, and will be described and illustrated in the Appendix, since their consideration would not advance the present pursuit of developments.

Two specimens representing work in the low-pitched category of roofing applied to lean-to situations exist at Rochester and Wells, and it is interesting to note that the earlier is an open roof designed to be seen and the later one is a diminutive high roof; this factual order of succession precludes any theory that the Rochester example could derive from the other. The Rochester roof shown in Fig. 43 is that of the south choir aisle which, in Hope's view,[39] came into its present state shortly

Fig. 42

after 1322; a section of one of the "rib" timbers is also shown but not drawn to scale.[40] This roof, in so far as examination from inside could elucidate, was designed to stand on the plates with their carved timber corbels, and from thence supported the flattish "pitch" by posts, purlins and wall-plates; while further support was provided by the curved arch-braces which were themselves tied back at mid-arc to the posts; and the whole, being provided with curved common ribs, afforded a ceiling for a plastered finish. Traces of original colouring have been recorded as surviving on the moulded main ribs, red for the "rounds", green for the "hollows" and white for the fillets. This colouring seems to vouch for the authenticity of the plastered soffit, but it is also possible that the common ribs were finished in some alternative manner and remained visible.

The similar roof shown in Fig. 44 is that of the north choir aisle at Wells, which was completed either in 1335 or in 1380.[41] The posts in this case appear to stand directly on the masonry, either at a vault-ridge or in a pocket; they are jowelled like those of the preceding example and they trap the purlins at their top-joints. The use of the short dovetailed keys to retain the purlin in the downward side of its brace appears to indicate clear thinking on the carpenter's part.

That there was a sustained development of roof-types which were both different and introduced apparently at different points in time

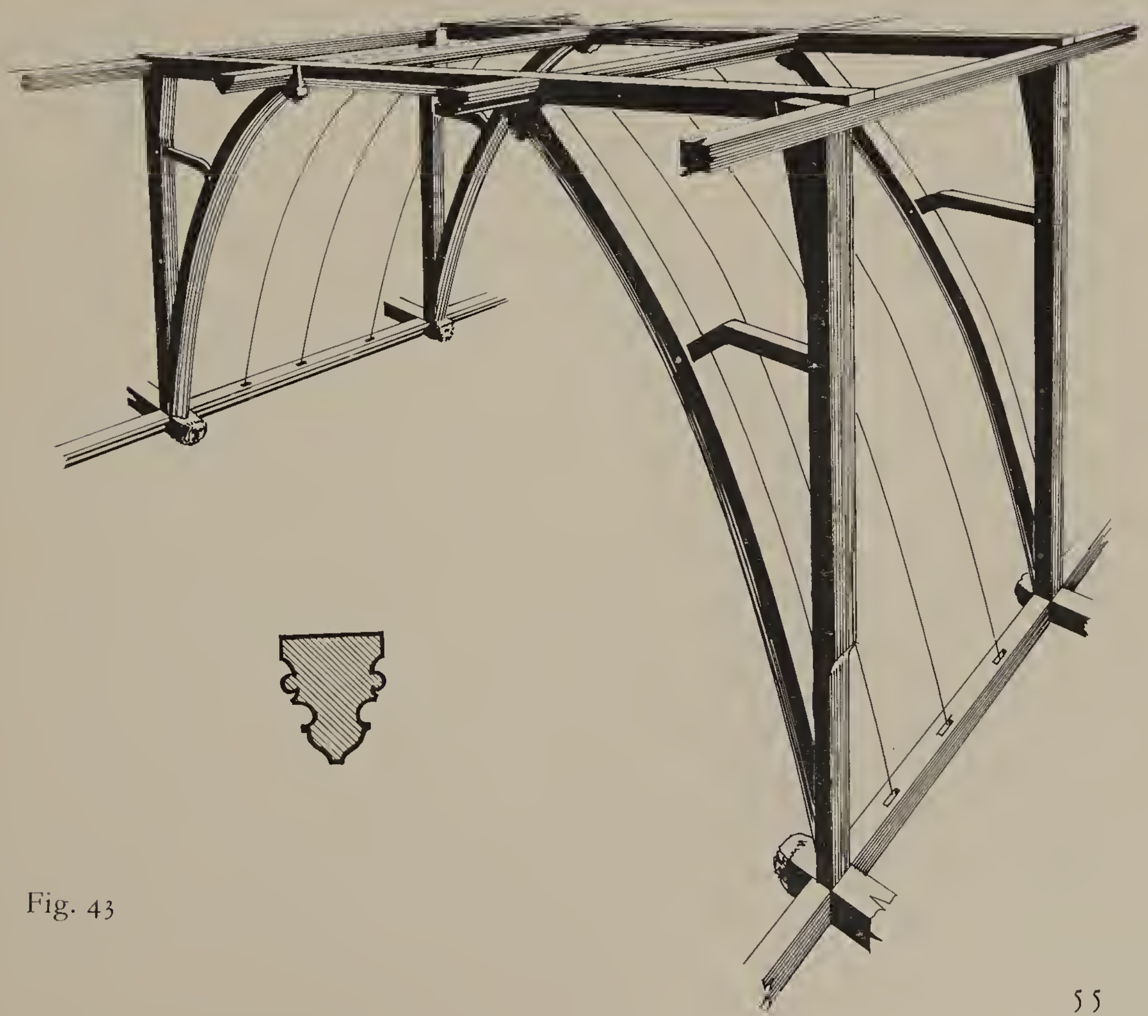
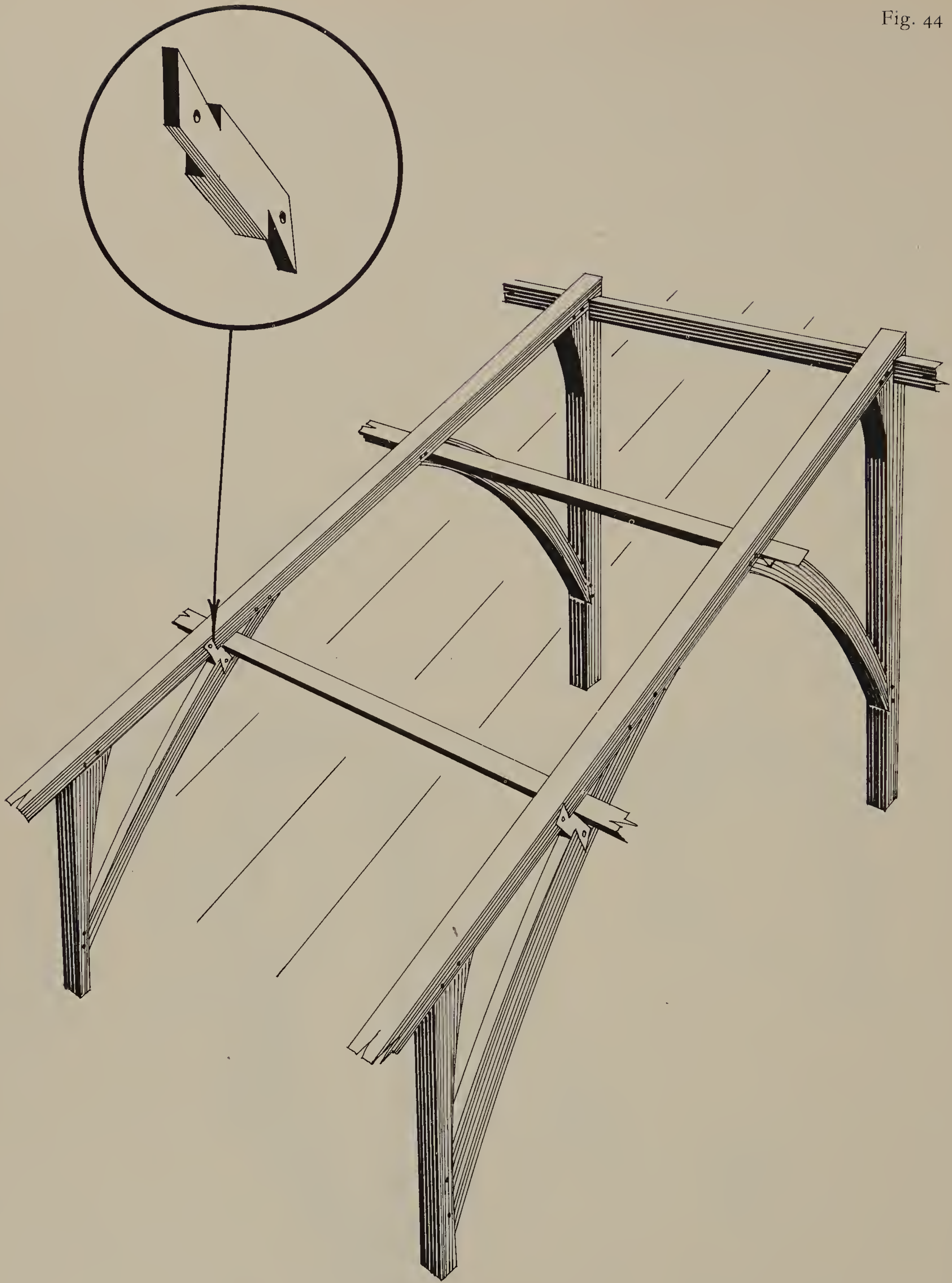


Fig. 43

Fig. 44



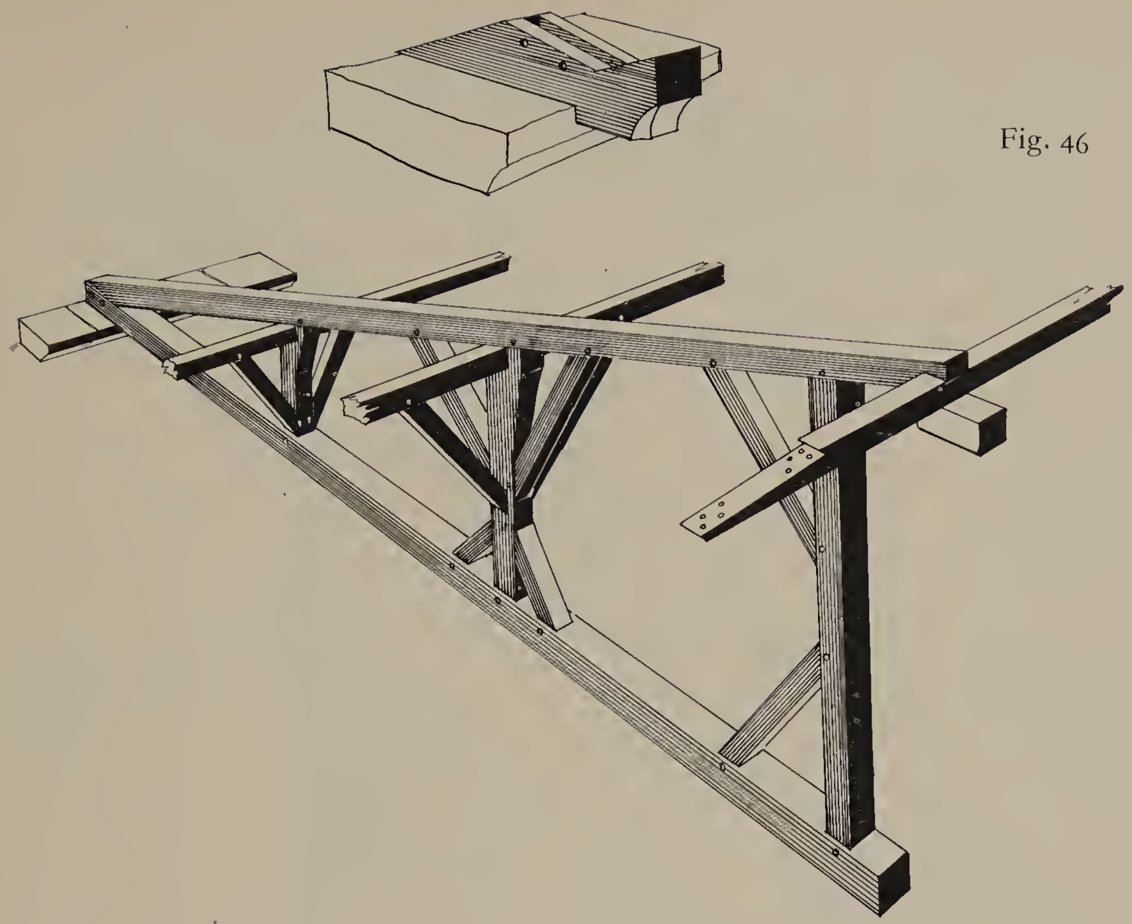


Fig. 46

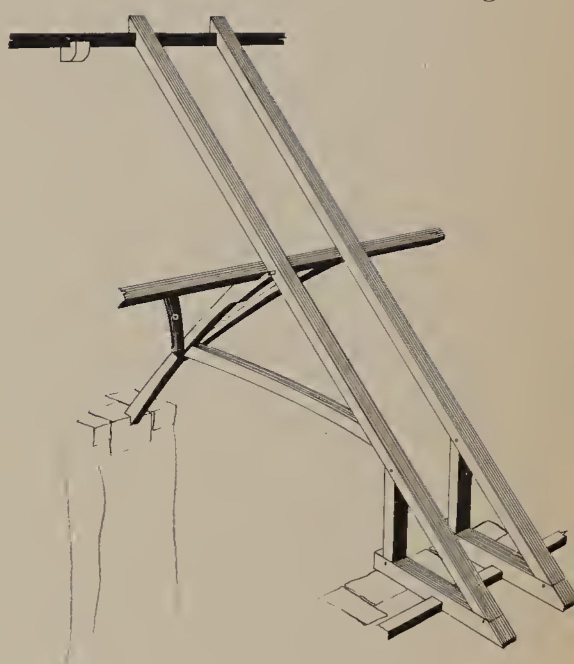
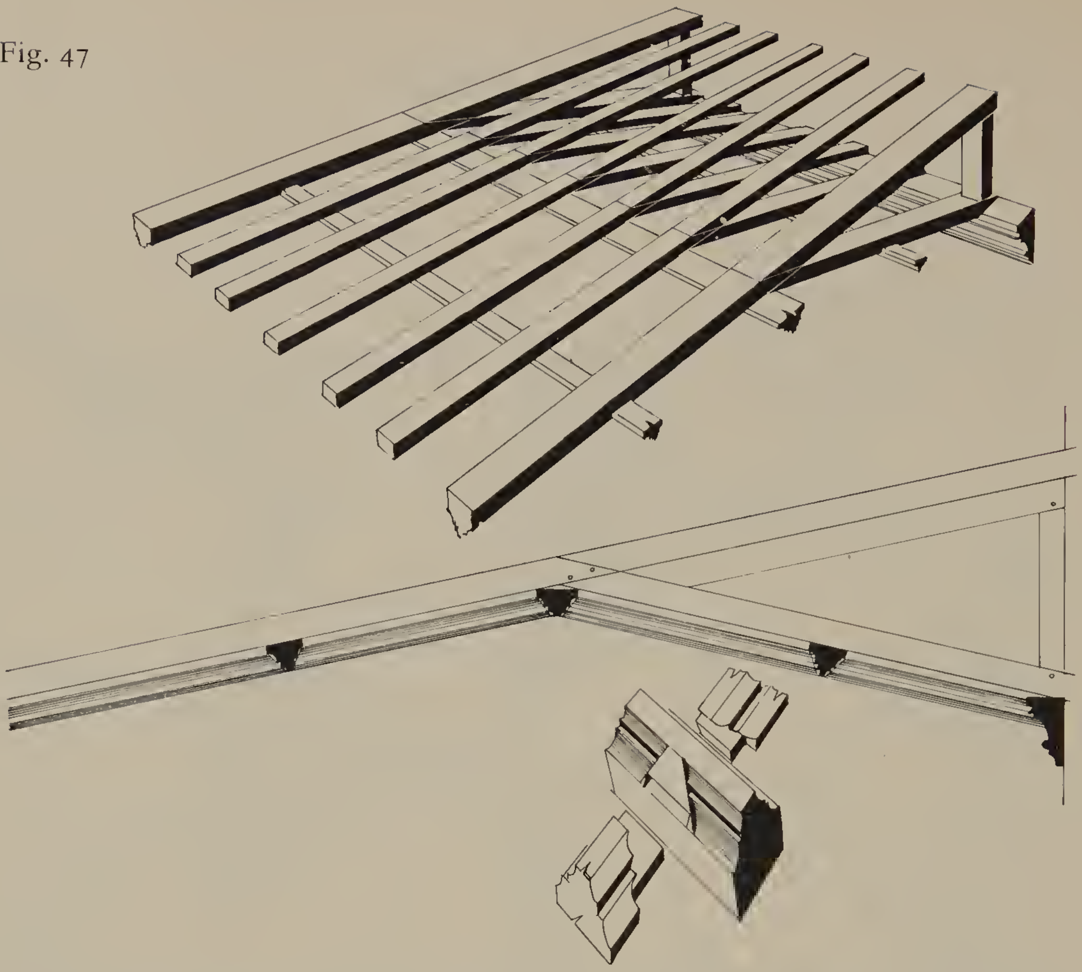


Fig. 45

seems supported by the example shown in Fig. 45, which is a small part of the almost bay-less triforium roof of the northern transept at York. The date given for the whole transept is *c.*1230,[42] and the date for the timber roofs to it *c.*1361–73.[43] Technically all of its rafters are common, since of equal cross-section, and like the earlier specimen of this type at Lincoln the sole concern evinced is to prevent the pitched plane from sagging—the introduction of the jowelled end seems, however, to have occurred during the intervening years. The roofs of the nave aisles at York are very different from any described hitherto and a frame from one of these is shown in Fig. 46. Their dating is difficult, but the date published for the fabric under them may help: the nave itself was built between 1291 and 1345, and the roofs of the aisles were possibly begun *c.*1300 and completed by *c.*1320.[44]

The frames, very low-pitched tie-beam examples, do not actually rest on their beams since the posts at the purlin's intersections are jointed with equal strength and efficiency at their tops as well as at their base, the frame thus produced being an inflexible triangle. The sole-pieces for the common rafters are all as the example shown at the top of the drawing, hooked over the arris of the outer wall's masonry, a device probably designed to prevent the rafters from sliding off the purlins—and one subjecting the masonry to only slight outward thrust, in view of the extremely flat inclination or pitch.

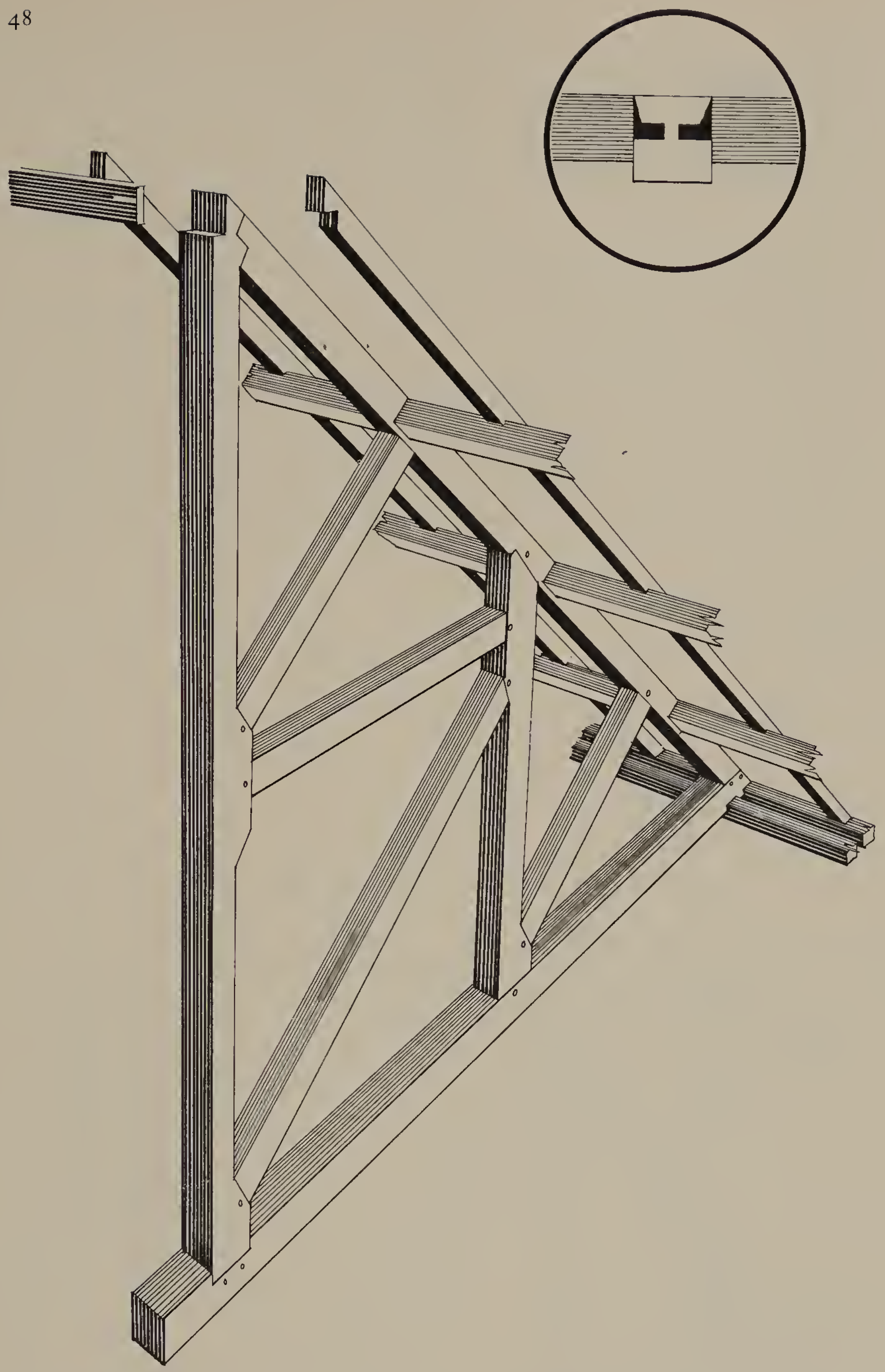
Fig. 47



Human ingenuity and the often unsuspected scope for sheer invention in situations relatively commonplace are well illustrated by our surviving triforium roofs, and perhaps second only to the carpentry display at Salisbury is the roof over the north nave triforium of Norwich Cathedral. A part of this is shown in Fig. 47, a study of which drawing will demonstrate that its construction is as deceptive on paper as it is in timber. While it cannot be recommended as a stable framing which imposes no strains on its abutments, it is a curiously devious example and is certainly unique in this country—unless something similar survives in some parish church. As shown in the drawing every rafter, either common or principal, is made of three jointed components; the first two of these form a ridged roof and the third converts this into a lean-to roof. No tying of its width was provided, and its existence must depend absolutely on the tightness of its joints at the centre, and the strength of its imposts. The profiles of the mouldings fit into a wide period of usage, anywhere between *c.*1370 and *c.*1550,[45] but since no tenon-haunches are provided it is likely to pre-date 1510 when these refinements were introduced at King's College Chapel in Cambridge. This roof bears no relationship to any other surviving in cathedrals, and is of great interest.

Abruptly, and with the next example, the medieval period and its understanding of hardwood carpentry that contemporary thinking

Fig. 48

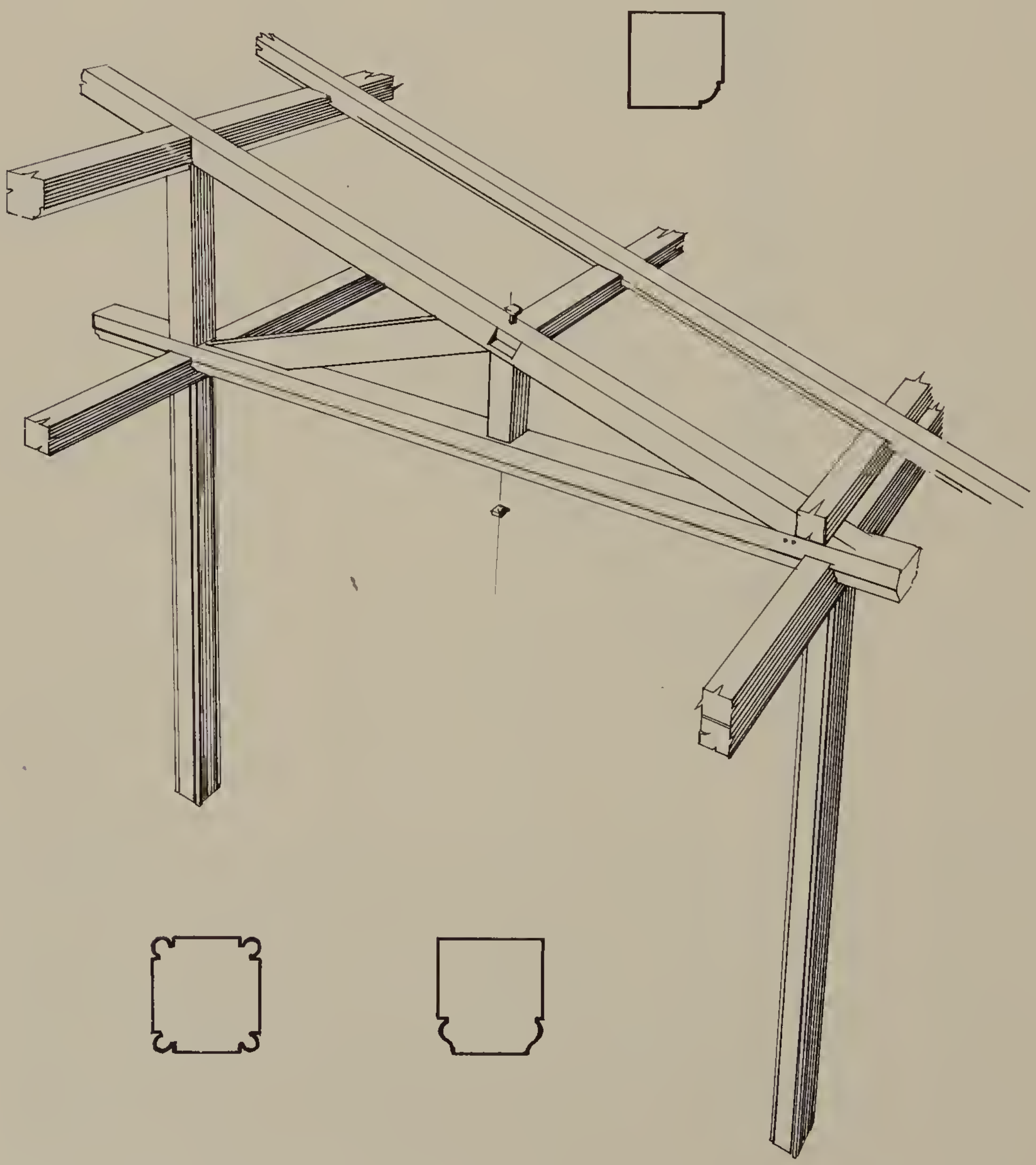


would not produce has ended; and with the existing southern triforium roof at Malmesbury Abbey we have fine carpentry, still of oak and owing nothing to the blacksmith, but more closely related to our times. The pitch in this case had to remain steep in view of the craftsman inheriting the situation and its limitations; but this roof provides a link with the nave roof over St. Paul's, which it may pre-date in view of the complete absence of ironwork or bolts. This is entirely made of good oak, well

jointed and pegged, with all surfaces apparently planed to a good finish. It stands upon the tie-beams, on the great strength of which it relies in order to preserve a flat inclined plane of roof-cladding. The purlins, three in number, were fitted by means of tenons with diminished haunches, as shown in the circular inset to Fig. 48. No documentary date is yet available for this work. The north triforium roof at the same building could not be seen when this was examined and is quite unknown.

With Wren's work, at the new St. Paul's, a firm date is again available, and the standard of carpentry is surprisingly high for that building, wherein great expense was evidently incurred to provide well-moulded timbers in all such situations as were to be subsequently visible. One frame of a triforium roof is shown in Fig. 49. This was a design that stood on points well below the level of the low-pitched roof-plane, supported

Fig. 49



on tall posts that were planed into the section having "rounds" at each corner that are shown inset, while the tie-beams were planed into cymarectas at their lowest arrises. All the oak timbers are very heavy for their functions and, although they are perfectly adequately jointed and pegged, they are in most cases reinforced by the means of iron bolts with threaded nuts. Critically, these frames are wasteful, in that they are overstrong for their purposes.

The north nave triforium at Lincoln is roofed in pine, with trusses as illustrated in Fig. 50. Some of the rafters used are of oak that is scarfed and presumably came from a preceding roof in this situation. The bolt which was fitted through a drill-hole along the centre of the posts, and locked by the nut let into an appropriate mortise, is shown in the drawing. This is a device not used by Wren, but also seen in the existing roof of

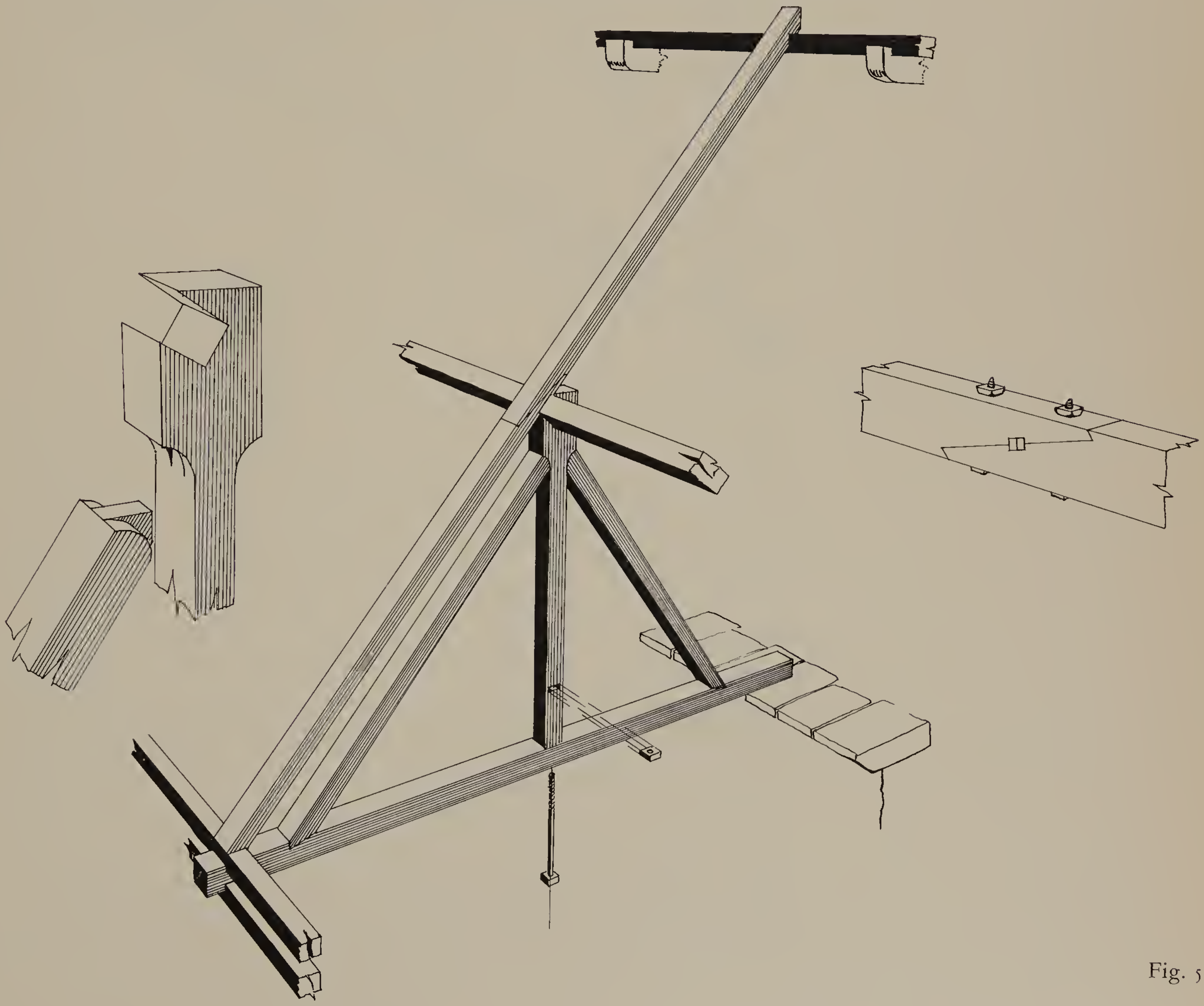
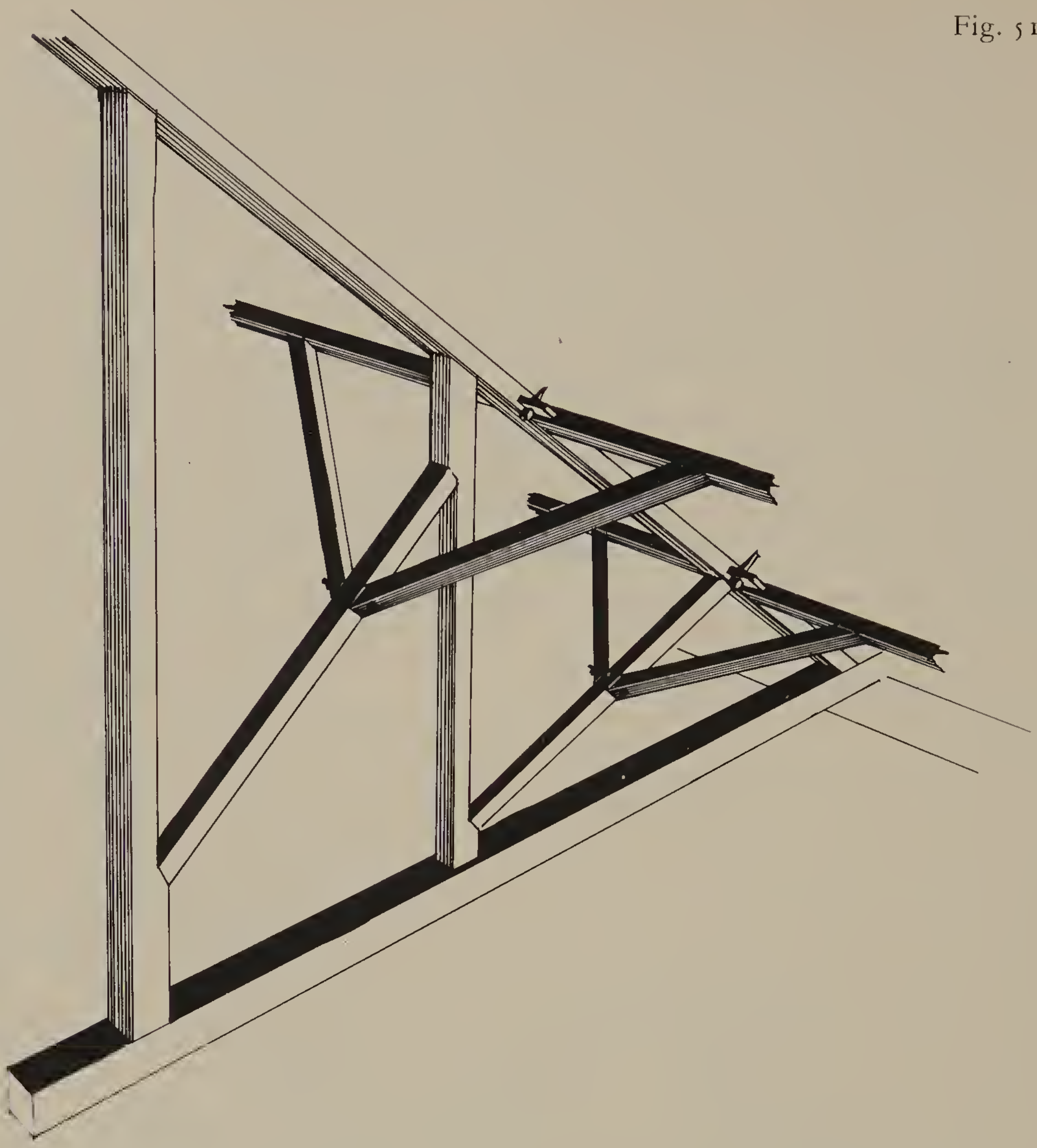


Fig. 50

Fig. 51



Henry VII's Chapel at Westminster, which is dated by inscription to 1785. A date during the close of the eighteenth century is also probable for this roof. The provision of "compassed" butment-cheeks for the shoulders of the two struts is interesting and apparently aims at two things: an entirely even and uniform distribution of the weight into the section of the struts, and also an abutment which would remain efficient if the post were to incline from the vertical. The scarfing is an attempt at progress, as the inset example shows; it derives from the mid-thirteenth century splayed and tabled joints that were closely integrated by driving a wedge, but in this case the folding-wedges provided apparently sought to achieve the same effect without the tablings. In parenthesis it was twice bolted through.

The western triforium aisle roof of the York Minster southern transept, which is illustrated in Fig. 51, is framed to resist racking tendencies. The side-purlins are tusk-tenoned and the bolts screw-threaded.

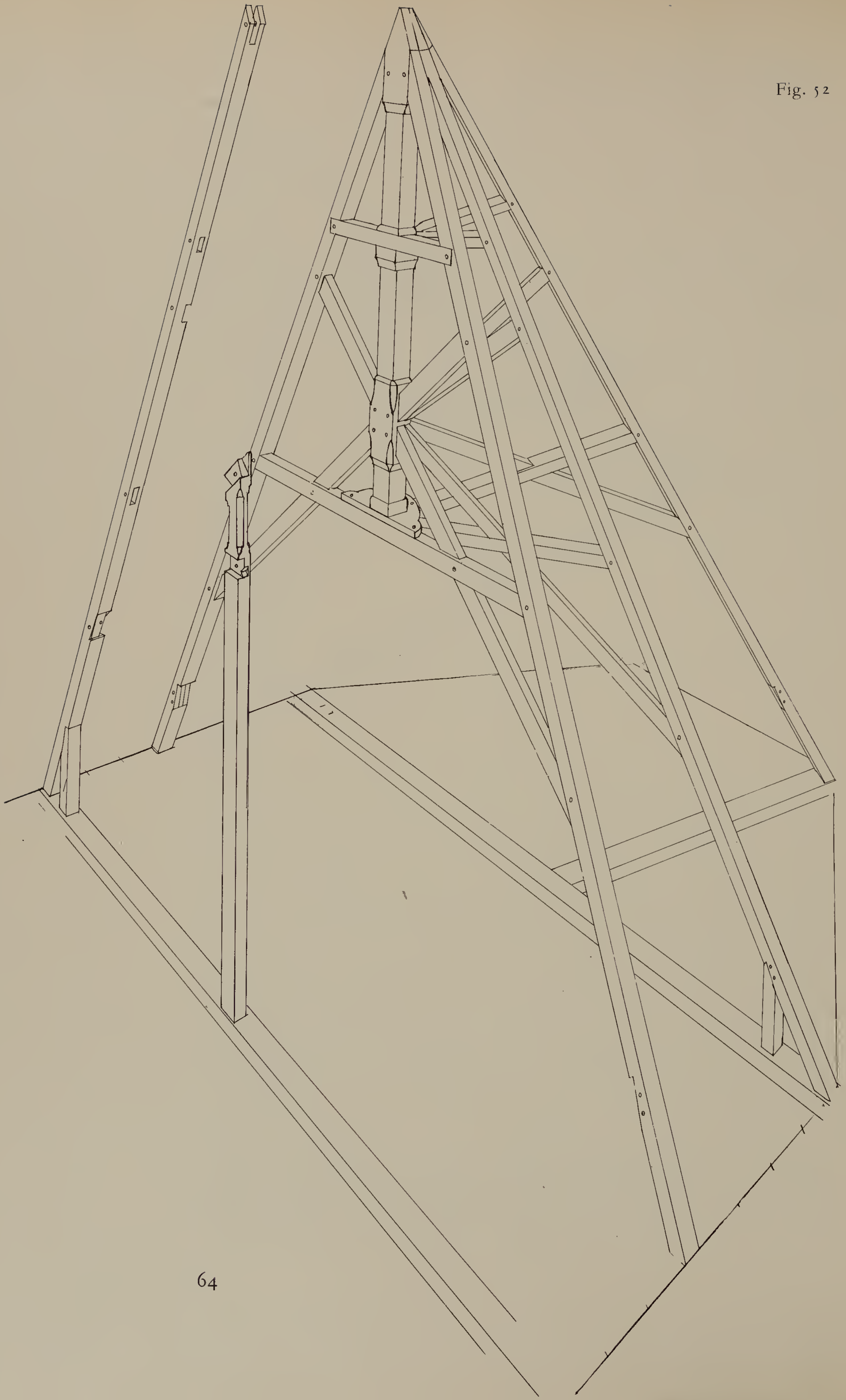
3 APSE ROOFS

The apsidal eastern or western terminations of churches both great and small have very few survivals, probably in view of their early fall from favour. Four such roofs exist today and, while so small a sample can tell us little concerning this sphere of the carpenters' activities, which must during the earlier medieval period have been much preoccupied with the undoubtedly difficult problems posed by the construction of this vertically halved cone-shape in timber to carry lead, these examples do relate very closely to the simpler roofs of their own times. The most splendid specimen is, without doubt, the great apsidal high roof over the eastern end of Westminster Abbey; this has, once again, been restored recently and so will remain for study in the future. As recorded by the Royal Commission[46] the original wall-plating and the eaves triangulations of the rafters had been repaired out of all recognition centuries before the present measures were taken to ensure its continued safety. Comparisons and deductions, therefore, are the only method by which a hypothetical reconstruction can be made; and such a drawing is given as Fig. 52—showing the apse as though viewed from within.

The three eastern arms of Westminster were completed by 1260 and were therefore twenty-three years later than the eastern arms of Salisbury, which were finished by 1237. Master Alexander, who was no less than the King's Master-Carpenter at that time,[47] used the "secret" notched lap-joint a great deal throughout both this roof and those of the adjoining transepts, while at Salisbury this joint was used very sparingly in the three eastern arms of the Cathedral. It is also possible that preferences on the part of nationally eminent craftsmen for particular forms of joints are irrelevant in such close dating-sequences as these, but some explanation is obviously desirable. That the Westminster apse roof is still the finest and, indeed, our sole national survival of such roofs makes it supremely important, while it is our only medieval specimen. All the preceding designs that led to this surprisingly complex and, to modern thinking, illogical solution of the problem are vanished, and only three later examples remain to compare with it.

The actual plan over which this roof was built is a five-sided one, so that the span is reduced between the two tie-beams shown in the drawing, and the king-post is mounted approximately half-way between these two

Fig. 52



beams. Against this king-post five virtually lean-to roof-frames rest, with half-collars and half-scissor-braces all tenoned into the thickest parts of the post. The rafters in each of these three sides of the apse are parallel (like those of the roof to York chapter house) and are tapered off and spiked to their converging neighbours. It will probably never be known whether any longitudinal timbers were intended in this roof, but if they were it seems certain that they were never fitted, for no evidence—even of pressure marks—has survived.

At Ely an apsidal chapel of St. Catherine projects eastward from the transept-like southern arm of the west end, and this possesses an oak-framed roof of unknown date. Its pitch seems to agree with the masonry-flashing, on superficial examination, and approximates to 45°; the roof itself seems likely to date from relatively recent times in view of its severely economical construction. It has two purlins in short lengths, tenoned into the principal rafters, and its common rafters run parallel up its diminishing facets, their numbers reducing as the apex is reached,

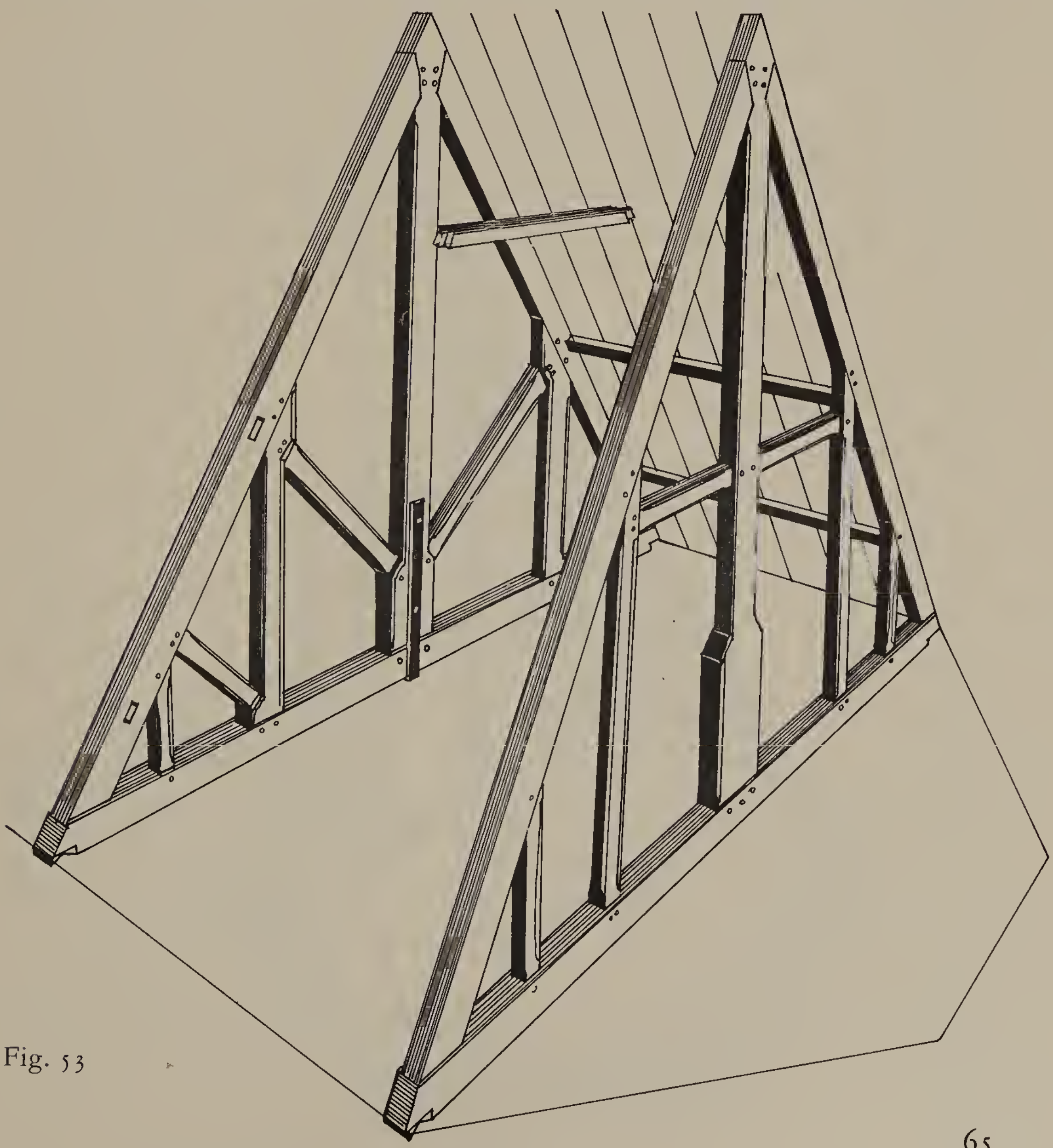


Fig. 53

above the highest purlin. The exact form of the tenons, whether refined or simple, has not been ascertained in this case and the dating cannot therefore be attempted.

The next example is that at Lichfield (Fig. 53), which surmounts the lady chapel, built *c.*1320–6 by William of Eyton,[48] but must apparently date from the massive restoration of 1661–9. This is again built as a three-sided half-conoid roof leaning against a king-post frame, fitted with queen-posts and a straining-collar. The hip-type rafters of the apse are forelock-bolted to the head of the king-post. Like the other Lichfield roofs resulting from this general restoration it is massively framed in heavy, chamfered timber, and indicates a very high order of costs. The common collars in the bay previous to the apse end, fitted in addition to the two side-purlins, show a closer affinity with medieval roofing than might be expected at this late date. Critically, the timbers are, like those at St Paul's, overweight for their purposes.

Finally, we have an apsidal roof at Pershore Abbey (Fig. 54). Built in three sides, this example leans against a king-post trussed frame like the previous one, but is far more elaborate, and its slender timbers were disposed in a more sensitive manner, and with more advantage. The date for this example, which is evidently a replacement, is uncertain but likely to be during the eighteenth century, if compared with others known to be of that period such as the Hawksmoor roofs at Beverley Minster.

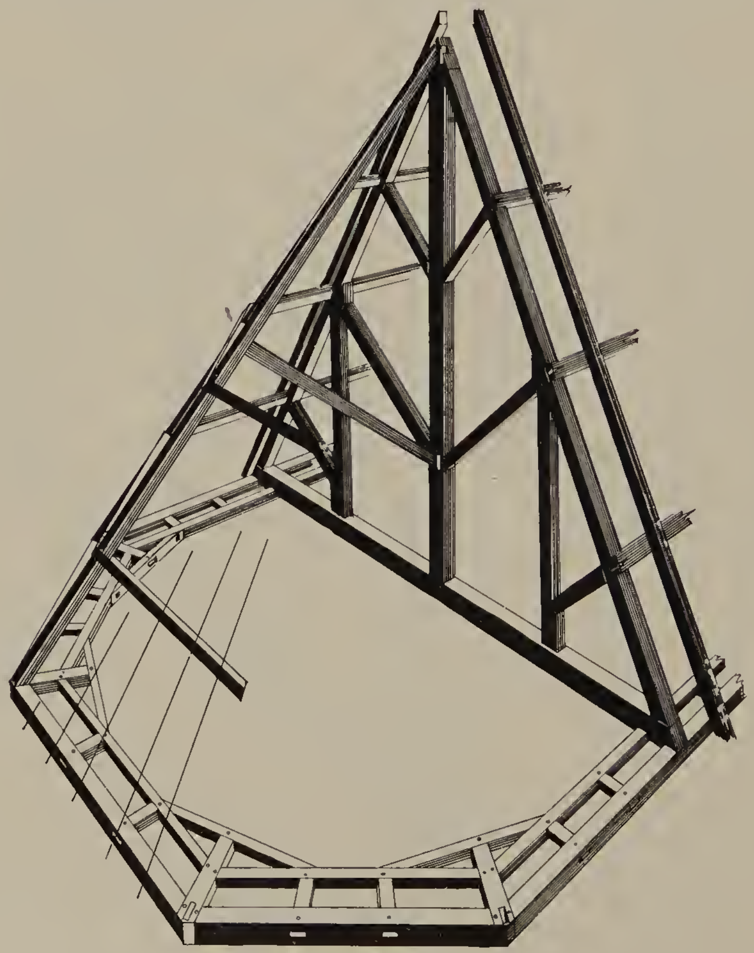


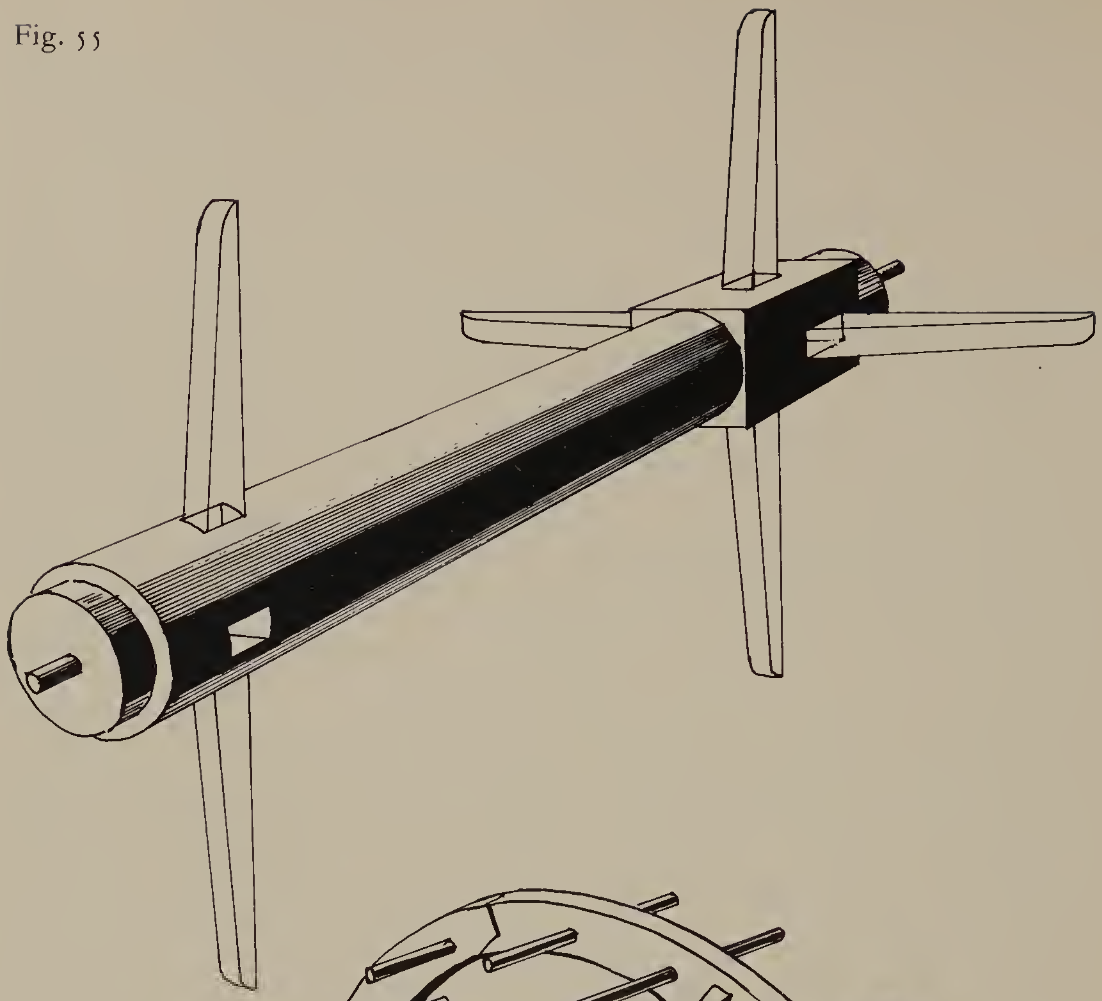
Fig. 54

4 HOISTING MACHINES

The huge quantities of worked stone and timber that had to be raised during the building of a cathedral obviously postulate the use of mechanical aids, and of these a few examples, comprising both windlasses and capstans, have survived. Contemporary accounts of the construction of these "engines" are quite numerous and, for example, Salzman in *Building in England* quotes Horman,[49] who in 1519 stated that "There must be made a trace wheel to wynd up stone", and also the Collyweston accounts which mention "a wyndes for to weyn up the timber". The principle involved was simply the winding of the hoisting-rope round the axle of a wheel—frequently a tread-wheel inside which the operator walked, thus raising the object attached to the rope's free end. These "great wheels" were either placed at some point of vantage, from which all lifting could be achieved, the rope being led through sheaves to the point to which the stone, timber or other materials were to be delivered, or—as at Westminster, where such a "great wheel" is described in the Abbey accounts—above the vaulting of the nave, being moved along, with the scaffolding, from one bay to the next. The most ingenious part of such contrivances would normally be the hook or hooks forming the "lewis" by which such an object as a keystone for a vault-rib could be attached to the windlass-rope and lifted. It is surprising that among the seven survivals of this type examined none were fitted with pawls, or ratchets, to prevent their running backward; this last would have been a great danger in cases where extremely heavy items were lifted such heights as ninety feet, a fairly common operation when building a cathedral.

Direct comparisons for the constructional details of such wheels can be made with those to be found in wind- and water-mills, and one major change in the design of wheels in all these three cases must be taken into account since it materially assists with any assessment as to the age of the wheel in question. This was the change from what were called "compass-arm" wheels to the type called "clasp-arm" wheels; at present numerous examples of both survive for study in the derelict mills of this country. The nature of this change affected the method of spoking the wheel: the earlier type had its spokes (arms) driven right through the shaft on which the wheel was mounted, and the second type had spokes that were

Fig. 55



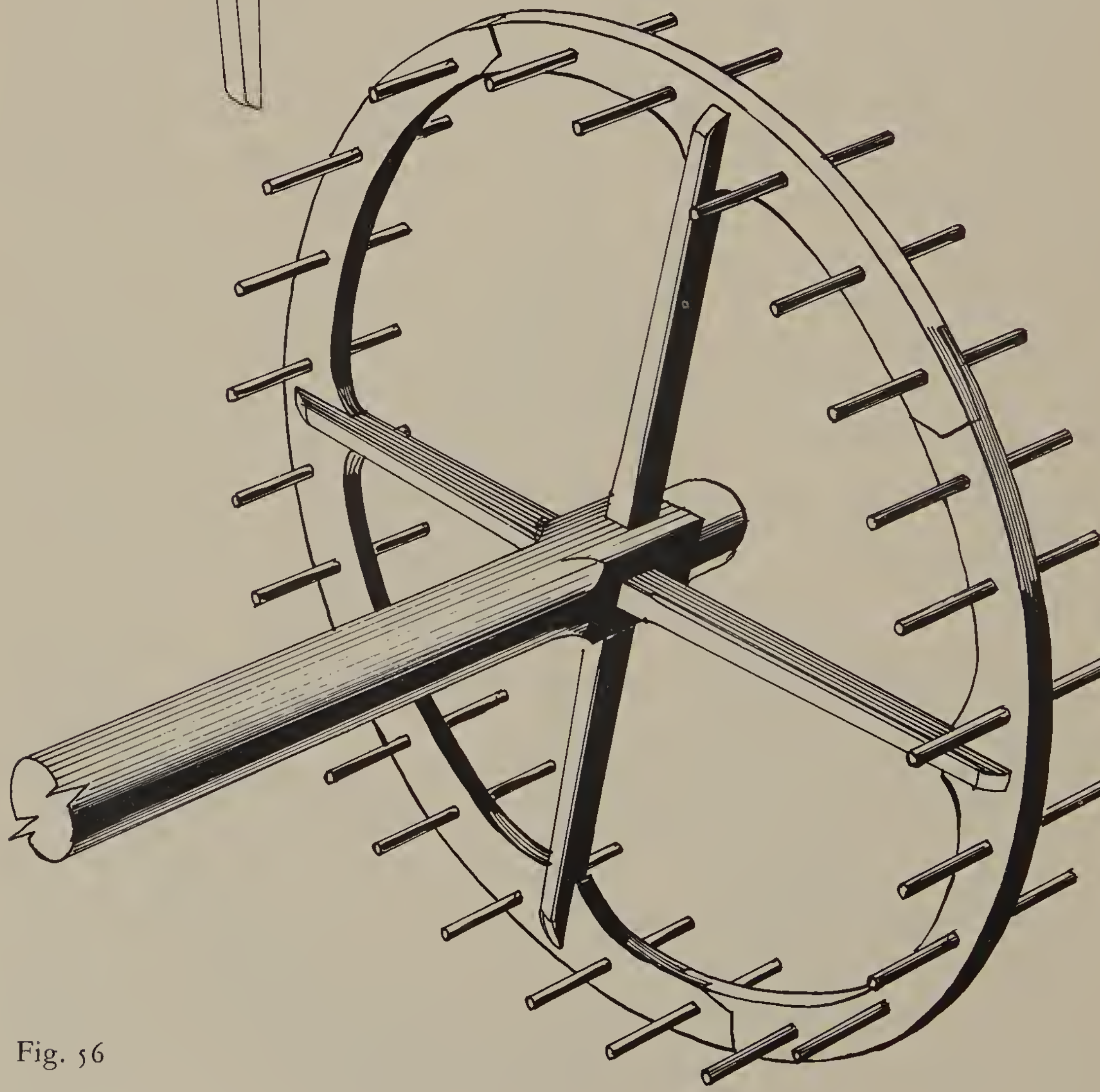


Fig. 56

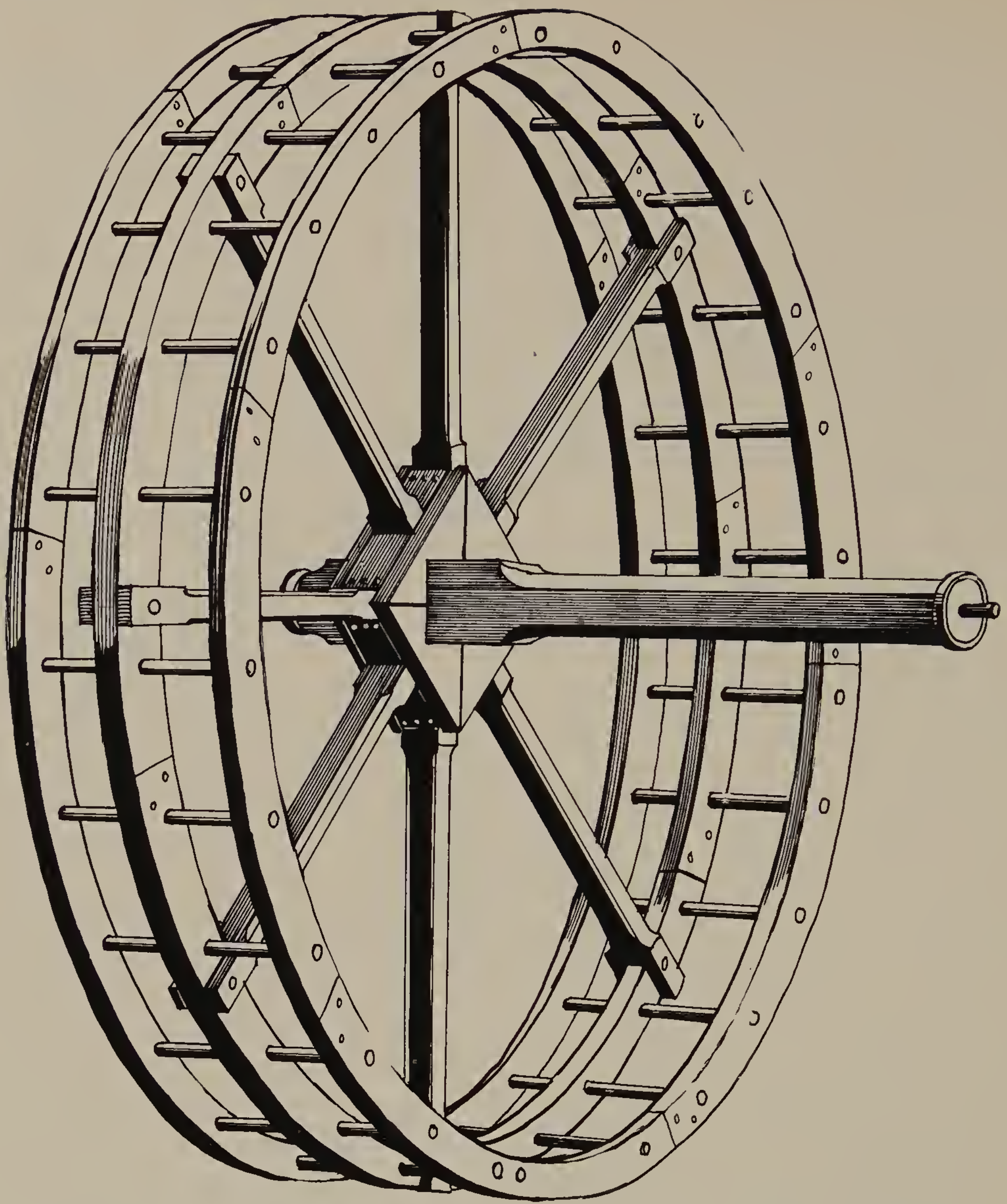
chords to the wheel's circle, and its shaft fitted into the square opening such spokes formed at their crossings near the centre. The earliest known illustration of the later kind of wheel appeared in 1556, and its invention is likely to have occurred sometime a little before that date.[50] This fact enables the surviving wheels in the cathedrals to be broadly classified as before or after *c.*1556. There are always people prepared to contend that such changes are not reliable dating evidence, since there was normally some transitional period during which both of two principles were mixed and produced a hybrid artefact, but none of the few cathedral wheels fall in such a category,[51] and the classification can reasonably be applied to them.

Two of these windlasses, of the earliest type of construction, exist at Durham and Peterborough cathedrals; the first is fragmentary, and the second is complete, with its framed mounting, and is in working order. The Durham specimen is mounted in the internal splays of a window in the north-western tower, the upper stages of both western towers being dated to *c.*1220[52]—not that such a fabric date is in any way relevant concerning the age of the windlass. This is illustrated in Fig. 55, and originally seems to have been fitted with a wheel at each end—both wheels having four spokes. None of the rim-segments or felloes have survived. A date at any point between that of the first building of this cathedral and *c.*1556 is therefore possible for the windlass, and only a Carbon 14 dating would satisfactorily determine its historical age. The two wheels would have been far too small for any person to "tread" them, and there is room for much speculation as to how this machine could have functioned. As to the possibility that this is a second-hand item of mill mechanism adapted for a different use, it must of course be allowed; but the likelihood of great cathedrals stooping to such acquisitions is slight, to say the least.

The Peterborough windlass is, as already stated, complete. This is shown in Fig. 56. The four compass-arms are nicely chamfered, and the four felloes are elaborately scarfed together at points between the arms; through the felloes are driven long, thick oaken staves, on which the workmen could either climb as on a rotary ladder or haul downward by hand. No close dating for this windlass is possible, but its form of construction renders it eligible for any date between the Cathedral's building and *c.*1556.

The windlass existing in the spire at Salisbury, which is still in use, seems to be a form which is directly derived—so far as its ladder-like rim is concerned—from the type at Peterborough. This is shown in Fig. 57. The precise method of its construction cannot be deduced and must

Fig. 57



await some such time as repairs are needed and the assembly can be taken apart. It is probable, however, in view of the likelihood that this may date from the building of that cathedral, 1220–58, that two of its compass-arms penetrate the shaft, while the four secondary arms are trapped by the box assembly which is spiked to the first four. The felloes of the three rim-circles are apparently scarfed together by means of tenons which possess radial shoulders—evidence as to this wheel being made by a specialist craftsman and to the highest possible standard. This machine is frequently supposed to date from the addition of the stone spire to Salisbury's central tower, but unless there is specific evidence to that effect in the archives there is no obvious reason why it should not date from the first building operations on the site.

The treadmill windlass shown in Fig. 58 is mounted in the crossing, above the vaults, at Beverley Minster. This one is clasp-armed, and there-

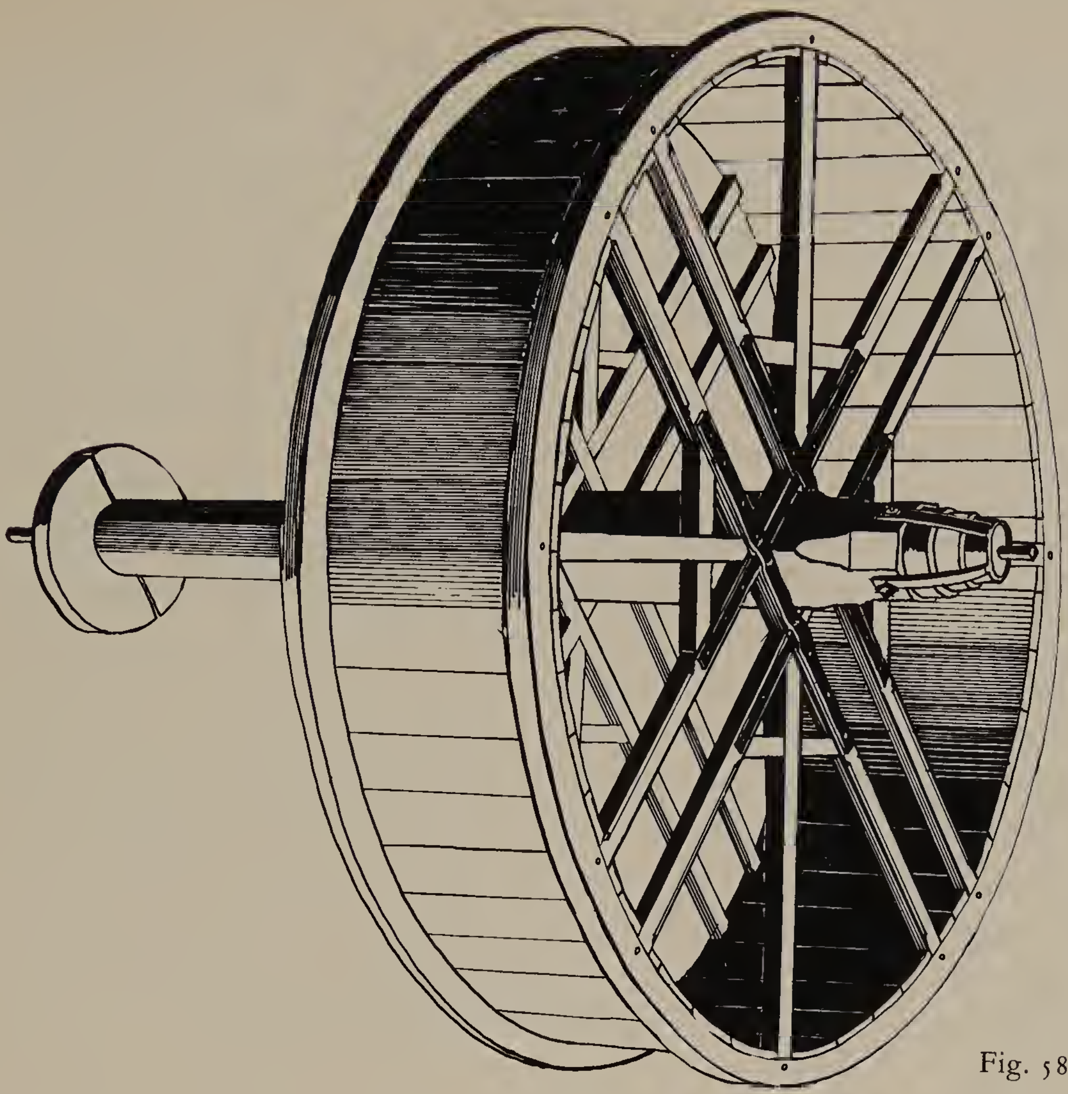
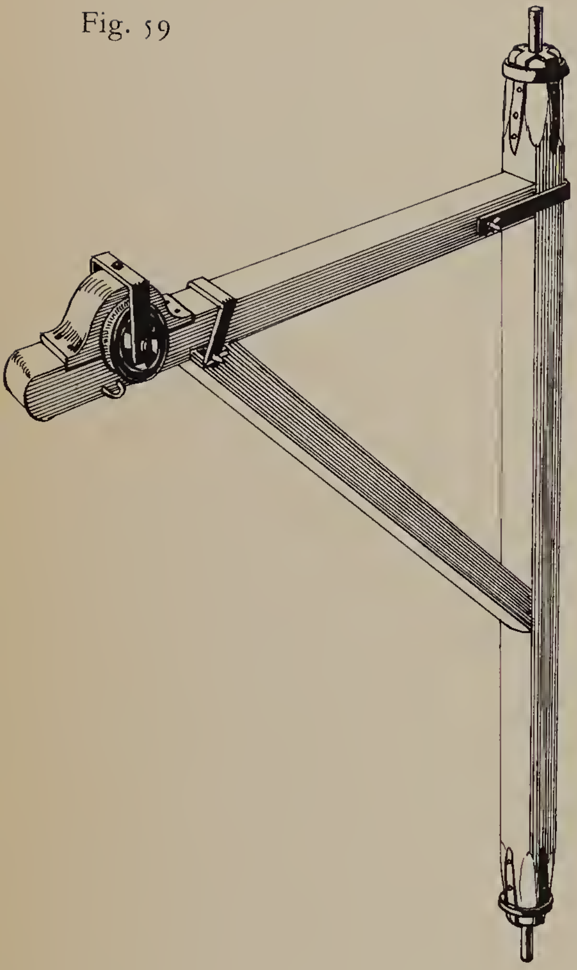


Fig. 58

fore must date after *c.*1556. According to my notes, written on site, the iron straps applied to the arms' crossings seem to be newer than the timber and represent reinforcements of the wheel. As in the preceding example, the need was recognised for secondary arms, which were fitted by halving them through braces to the primary assembly of two pairs, crossing about the shaft, which was left square at that point—as was usual. This need was occasioned by the treadmill function, which necessitates a rim-walk sufficiently strong to bear a heavy man. The stop-chamfers worked on the arms are of cyma-profile, and this example is another that is in working order—often proving useful.

The contrivance illustrated in Fig. 59 is an example, it seems, of what was termed a "faucon" at Winchester in 1257, which is otherwise cited in early documents as a falcon or hawk. Today it would be defined as a "jib"; the article survives at King's College Chapel, Cambridge, where I am told it has lain in the northern passage at the level of the vaults for the past forty years. Unfortunately the engine, or windlass, to which this jib is complementary, has not survived. This fitting was evidently wall-mounted, like the similar ones still to be seen beside the "loop-holes" or

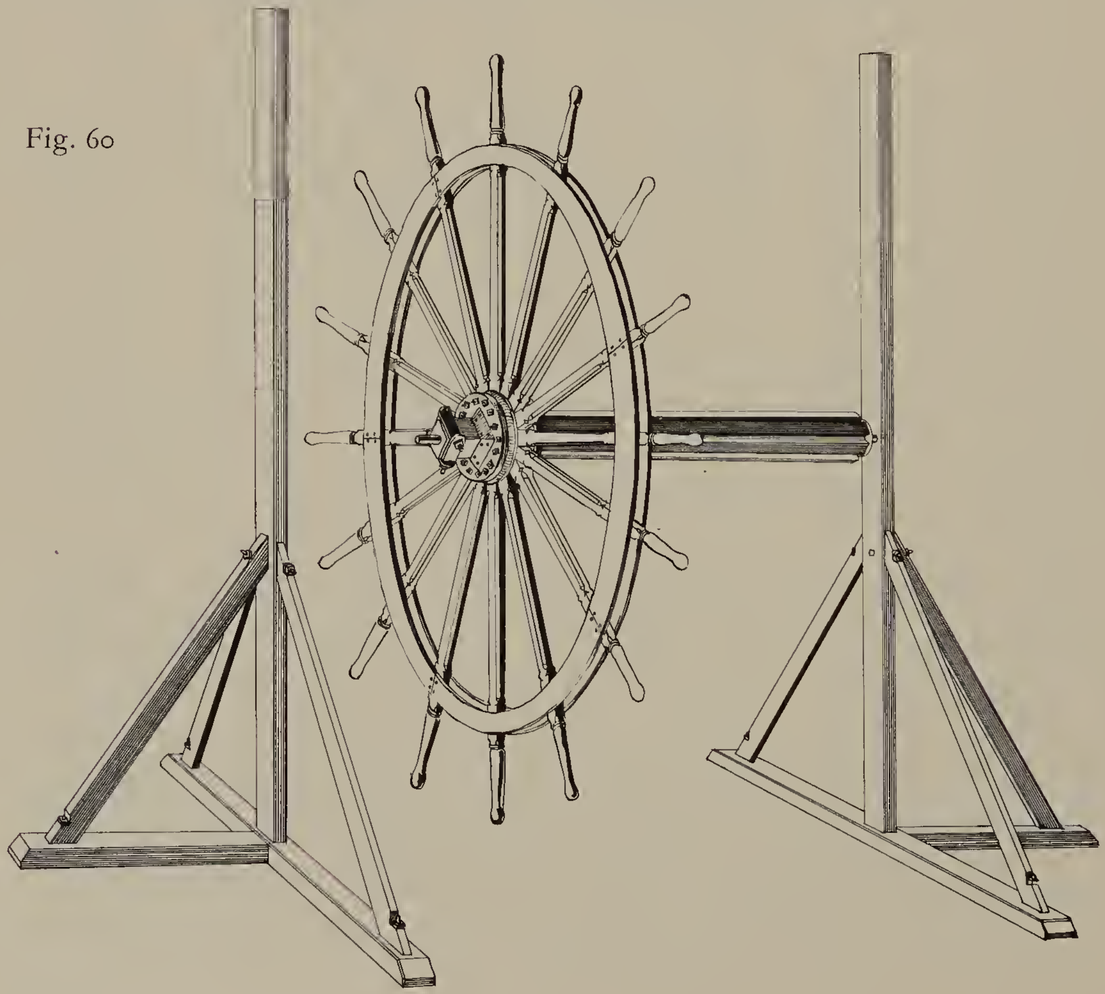
Fig. 59



upper doors of warehouses, and could be swung through 180° in the horizontal plane. It is assembled most carefully and reinforced with strap-irons affixed by forelock bolts. This last feature implies that a date before *c.*1700 is highly probable, and in fact a sixteenth-century date seems probable if the design of the brass pulley-wheels or sheaves is any indication.

The hand-operated wheel and windlass in the spire of Norwich Cathedral is illustrated in Fig. 60. This is another example in good working order. I am given to understand that this is ascribed to the eighteenth century, but do not know upon what grounds. There is no obvious reason why it should not date from the seventeenth century. The use of threaded nuts and bolts clearly places this specimen later than any hitherto described, but does not help with a specific dating. The construction is quite different from the medieval ones and depends on two circular discs of elm that are mounted on the squared part of the shaft; between these discs the spokes are then bolted while the two thin oaken rims effectually stay the spokes in radial positions. The final example (Fig. 61) is the capstan which is vertically mounted in the south-western tower of Durham Cathedral. This is entirely made of pine and probably dates from the eighteenth century. The reason for fitting both the capstan-bar and the short handles is not clear; but both are apparently original.

Fig. 60



Some idea as to the size of these devices can be obtained by remembering that the tread-wheels afford clear head-room for a man to walk inside, standing erect; while the hand-wheel at Norwich is mounted so that the horizontal spokes are at eye-level, in which position the lowest one just passes the floor. Just how great an advantage these devices gave is not known, but is clearly calculable from ordinary mechanical principles. It does not seem in these cases that they were provided for the raising of the heaviest items, but rather for the more continual uses of raising relatively light and frequently needed building materials, such as stones and mortar.

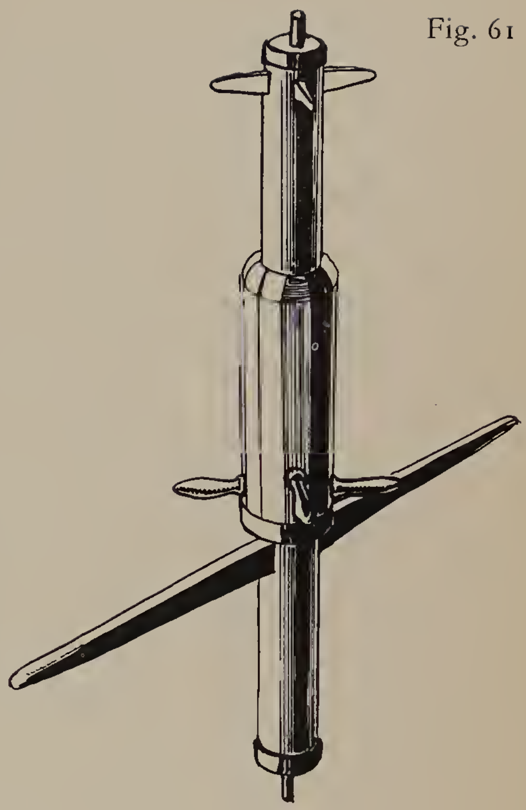


Fig. 61

Three further examples are known to exist, but these have not been examined and are not illustrated. One is a walk-wheel situated in the Bell Harry Tower at Canterbury; and two other devices exist at St. Paul's, London, where a vertical oaken capstan is fitted into the north-west bell-tower and a wooden-barrelled iron-geared windlass, with reduction drive, is mounted above the Golden Gallery and beneath the Ball. Of these two, the capstan is likely to belong to the building operations of that cathedral.

5 POLYGONAL CHAPTER HOUSE ROOFING

The chapter house at York Minster is dated, structurally, to the period *c.* 1285–1300 by J. H. Harvey. The outer carcase of masonry has apparently been altered and its height increased, when a trabeation of further masonry was built between the upper part of its buttresses and the angles of its octagonal walls. Its timber roof, which is in the form of an obtuse spire, is of doubtful age since its lower parts incorporate notched lap-joints in great numbers, in addition to a doubling of the framing at eaves level. Were the roof to date from the period before the buttresses were raised, it must have been raised with the stonework at that time.

The clear span of the building is fifty-eight feet, and this was bridged by "built" tie-beams, as shown in Fig. 62, which gives a plan of the "floor" framing at eaves level. To produce these two very long timbers were forcibly pinched together at each side of the central spiremast when extending timbers were trapped between their ends. The two bent timbers were themselves trapped by the form of their crossing-joints at the point where they passed the side timbers of the square void. From a study of the plan it will be evident that all the subsidiary timbers of this floor radiate, approximately, and the ring of post-sections shown are of alternating functions: those shown hatched are cant-posts rising within the spire, and those shown in black are pendants which descend to support the ribs of the timber vault beneath. The plan-pattern of the vault is shown in Fig. 63: it is one of the examples without a central pier and therefore requires support from the timber roof above.

The conoid, octagonal roof is shown in Fig. 64 in perspective as it is mounted on the floor described, from which drawing enough timbers have been omitted to clarify matters, it is hoped. The height of the spiremast is approximately sixty-four feet; this is built in short parts that are scarfed together and is of octagonal cross-section. A precise order of assembly for this beautiful structure has not been worked out, to my knowledge, but it would have been likely that the octagonal "ring" of wall-plates with the radially disposed and massively framed "brackets" were assembled first—as was clearly possible within the open upper "ring" of the masonry. From that point assembly could proceed, with the four tie-beams enclosing the lower piece of the mast, being followed by their braces forming the smaller square at the centre, followed in turn

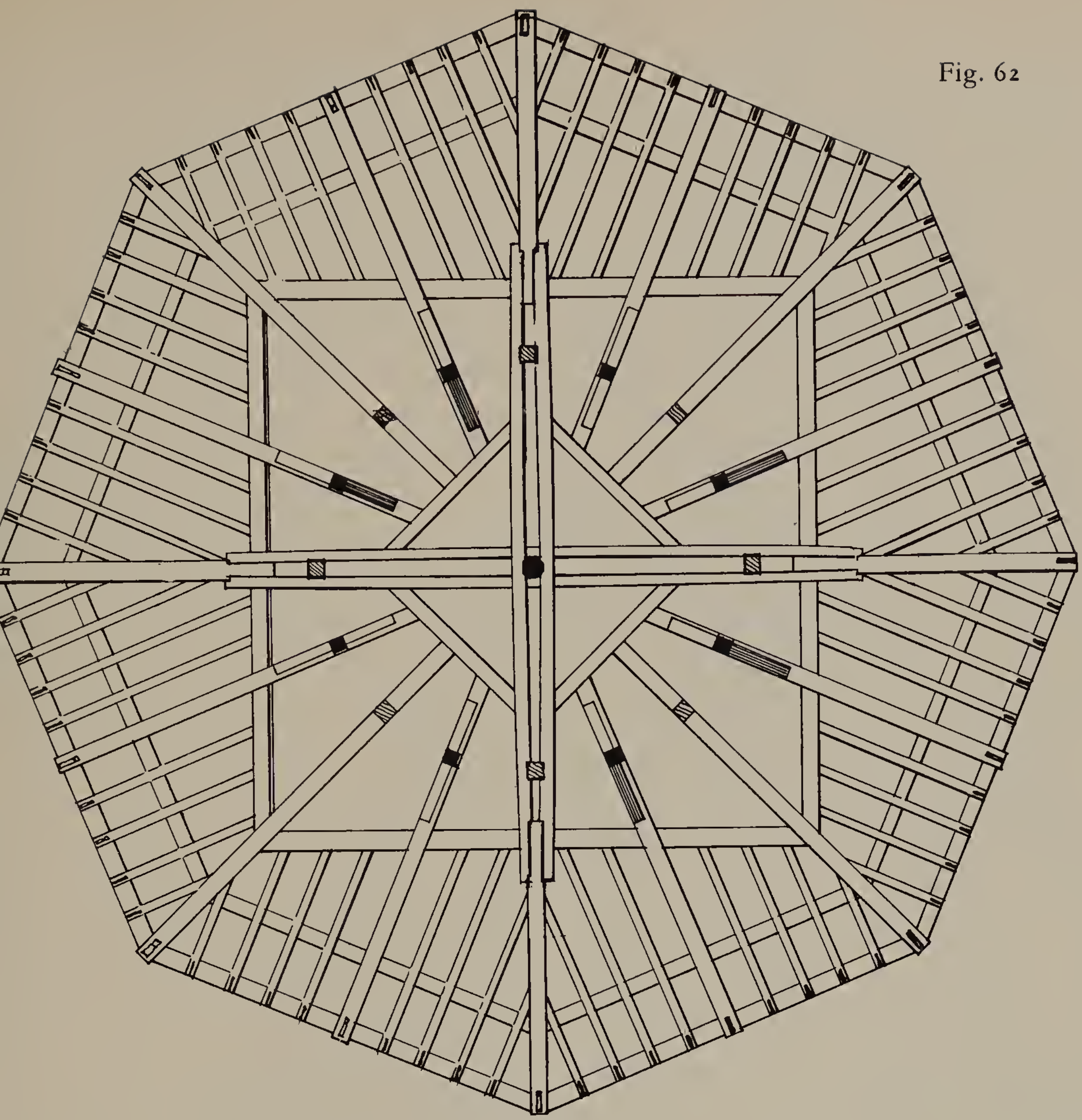


Fig. 62

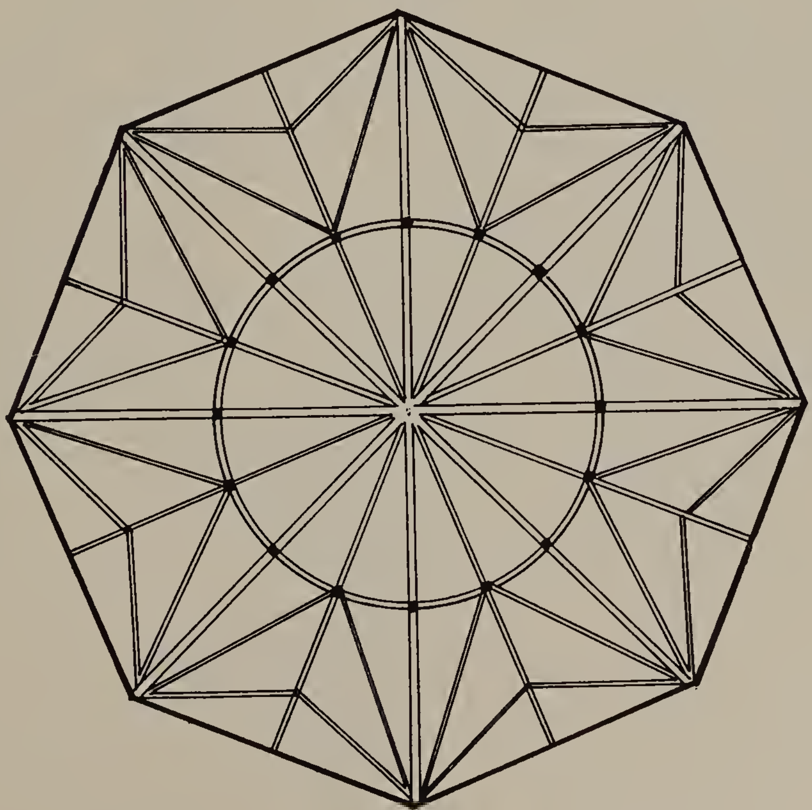


Fig. 63

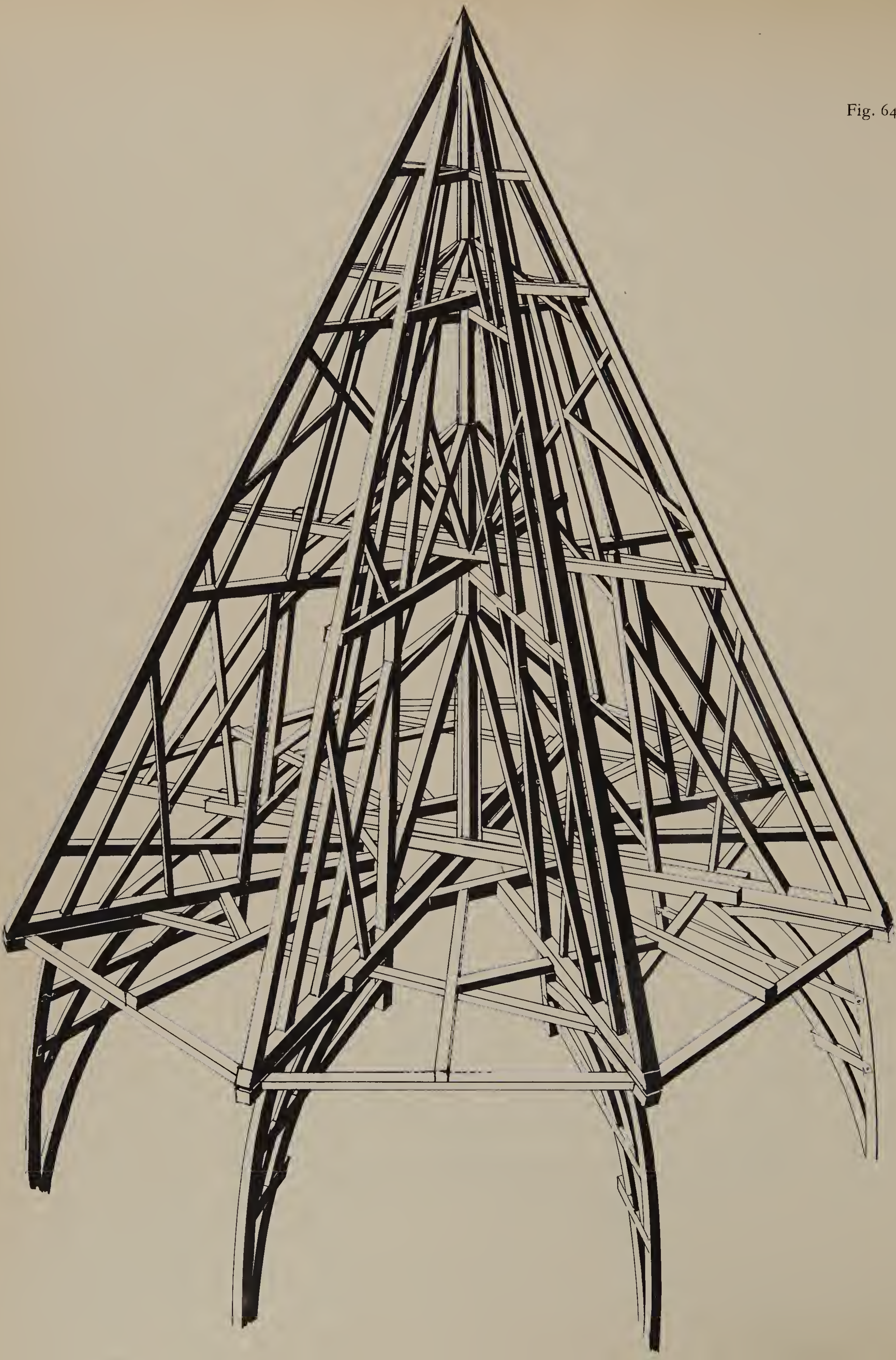


Fig. 64

by the four tie-beams tenoned into the smaller square. The wall-plates were set into the lower ties with pairs of single tenons. The spire could from that point be built, in a series of stages, each integrated with the one beneath. It appears, from the disposition of components inside this cone, that the weight is fairly dispersed—in a manner dividing it between the central mast and the major square which transmits it, through the brackets, to the buttresses.

Of less complexity but equally impressive is the flat roof of the chapter house at Salisbury, which was built *c.* 1275. This is shown in Fig. 65, without its surrounding masonry. By comparison with the preceding work this must have been "child's play" to the medieval carpenter and architect, the latter being Richard Mason in this case.[53] This is a building with a central pier, and so its timber roof is centrally supported on an extension of that pier, in octagonally sectioned oak, with a carved capital of which the profile is given in Fig. 66. The weight is thus divided between the central pier and the peripheral stone octagon-wall with its angle-buttresses, each radially disposed rafter being supported by curved braces at four points in its length, while the weight is transmitted lower down into the masonry angles. Fig. 67 also shows the scarf used for top-plates, and the form of chase-tenons used for the rafters' braces—both further discussed in the Glossary.

The next specimen has a similarly flat roof built radially from a central

Fig. 66

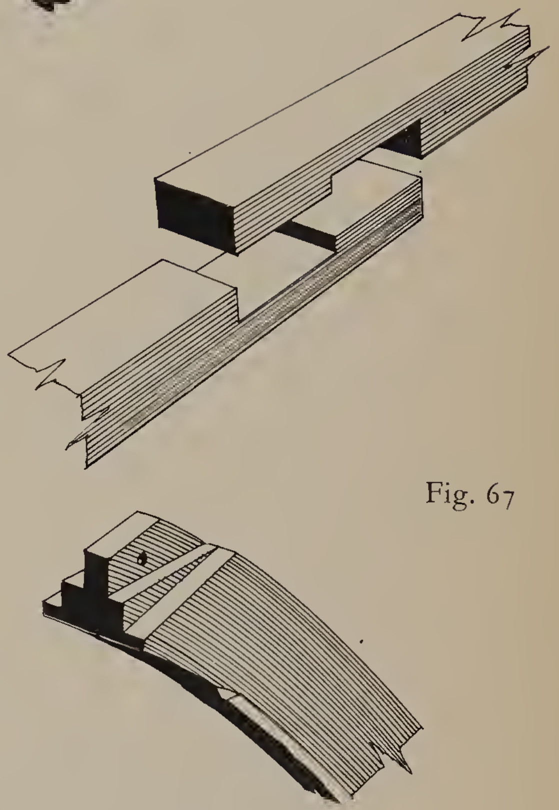


Fig. 67

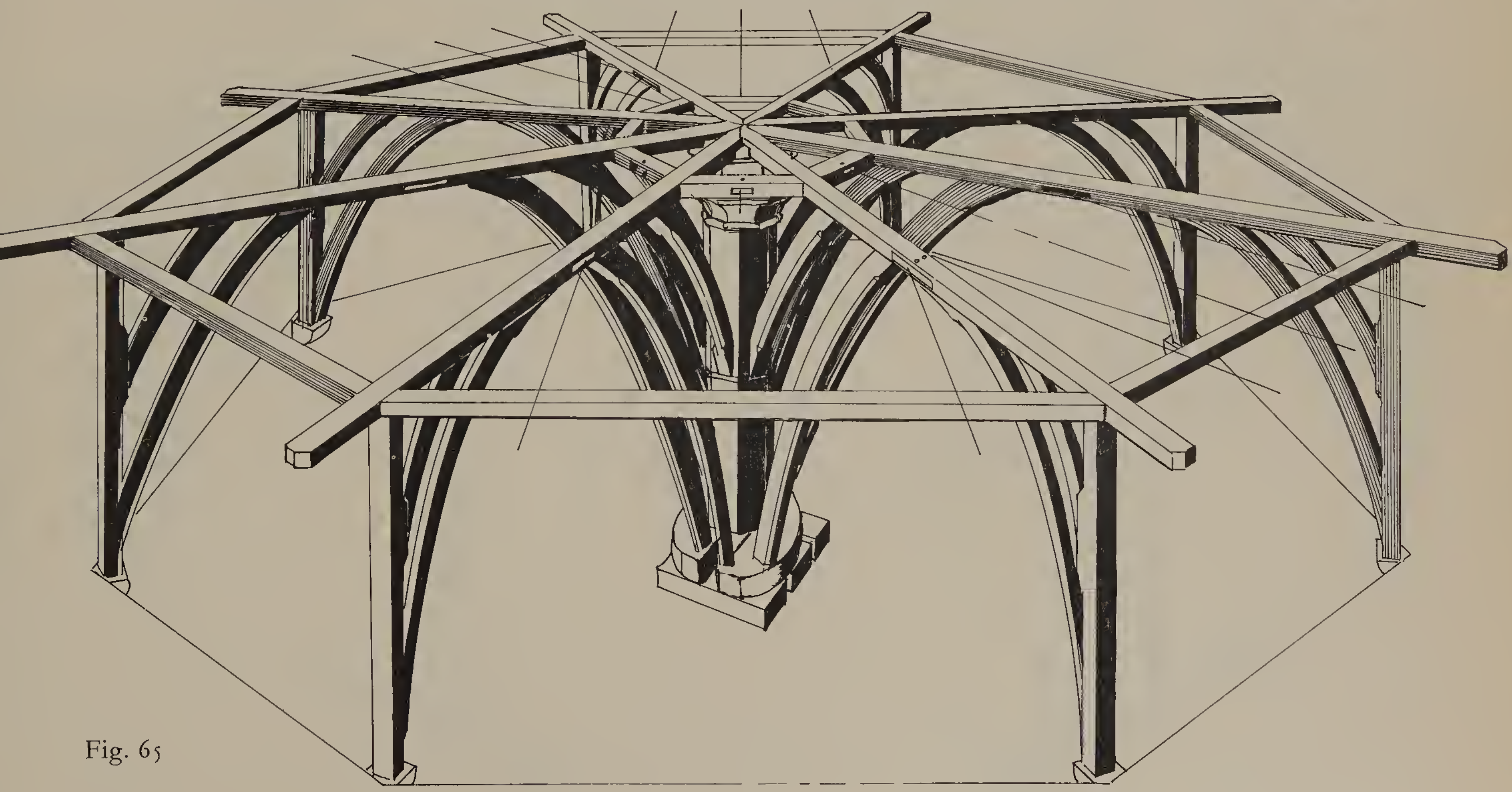


Fig. 65

pier of timber which stands in the vault's central pocket. This is the chapter-house roof at Wells (Fig. 68), which was completed by *c.*1306. The difference in this case is the transmission of part of its weight, by means of an internal ring of posts, onto an octagonal plate which follows the vault-crown. The weight is thus divided between the central pier, the crown of the vault and the peripheral walls. The scarfing of the timbers which form the octagonal plate is shown in Fig. 69. This is ingenious, and the joints are deliberately situated upon straight lengths, in order that the corners have maximum strength. The chapter house at Worcester is circular and is dated to *c.*1120,[54] and its architect is as yet unknown. The timber roof is apparently not the original one and is illustrated in Fig. 70; this is a similar and apparently derived form—from the Wells and Salisbury examples. Like Salisbury it concentrates most of its weight onto the central pier, which is extended by the timber post from which radiate straight, tied braces. The peripheral wall-posts spring curved braces that are also tied. The three purlins are set parallel and as chords to the circular outer wall. The restoration of its vault and roof, and the insertion of Perpendicular windows, was between 1386 and

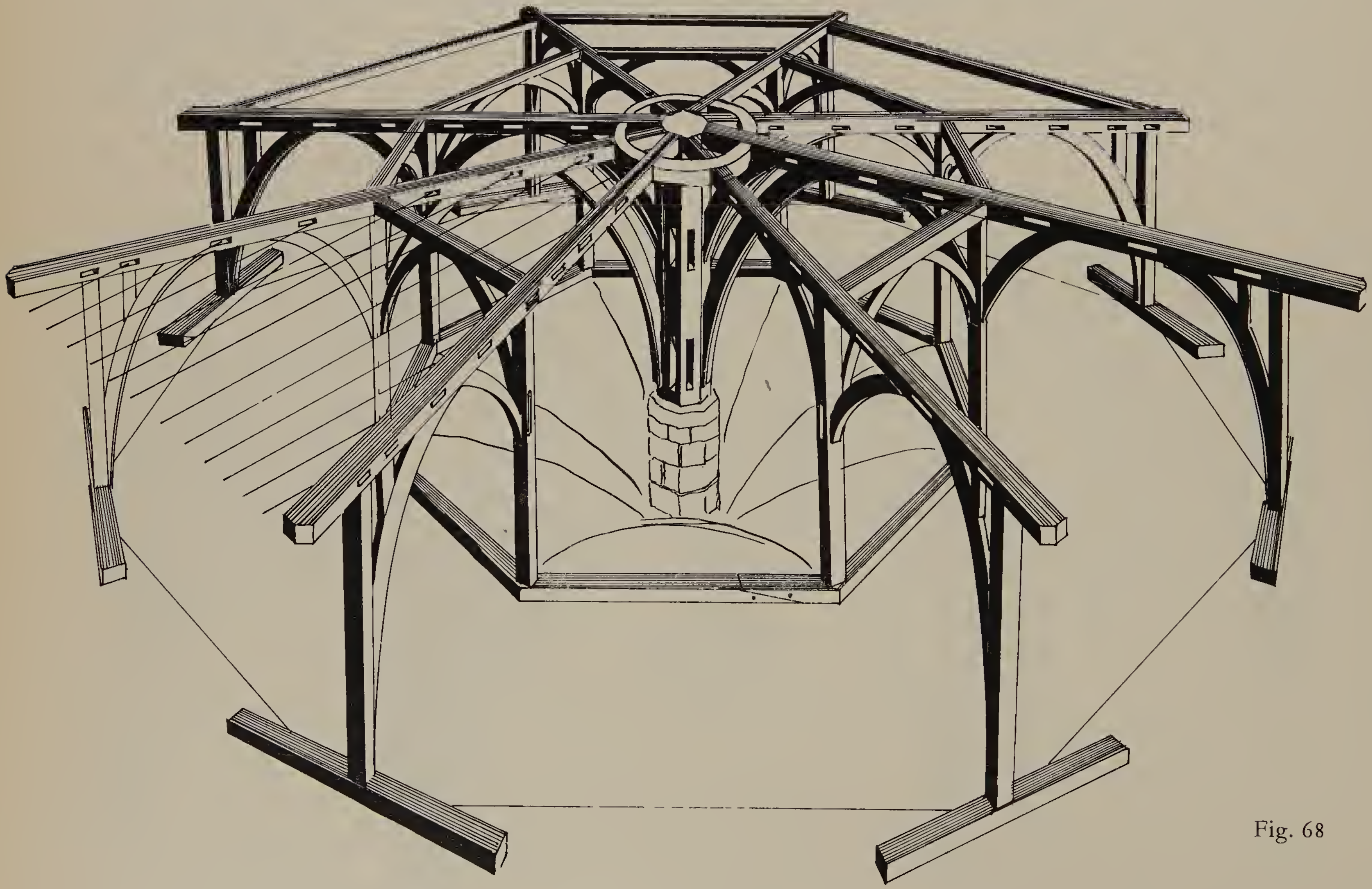


Fig. 68

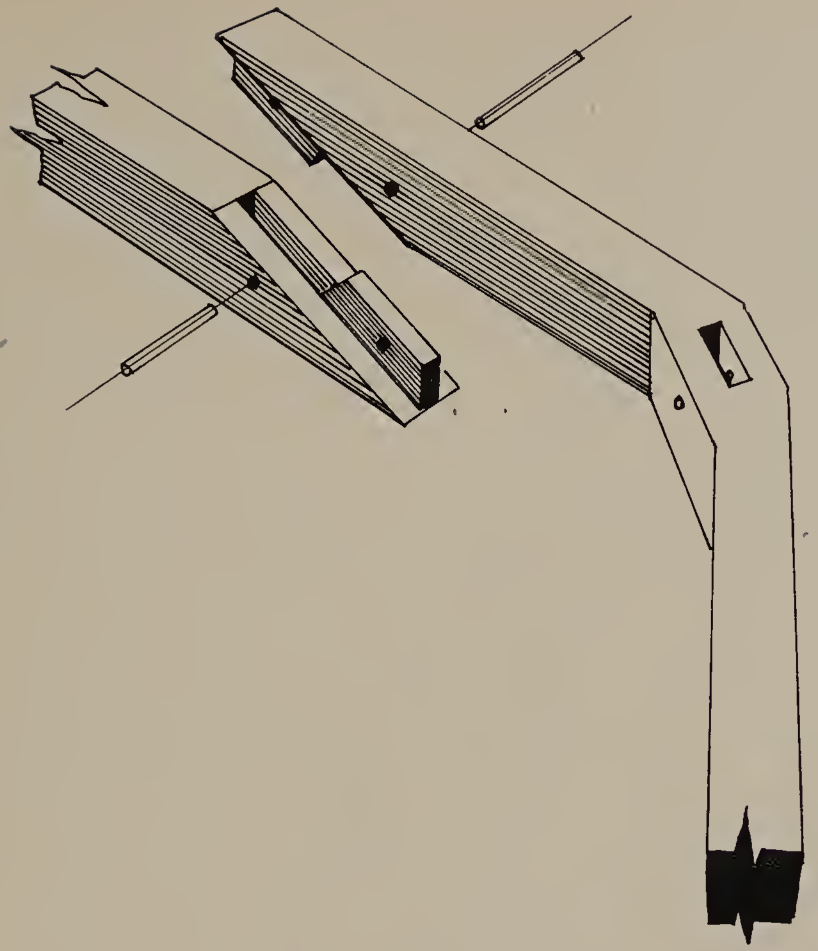


Fig. 69

Fig. 70

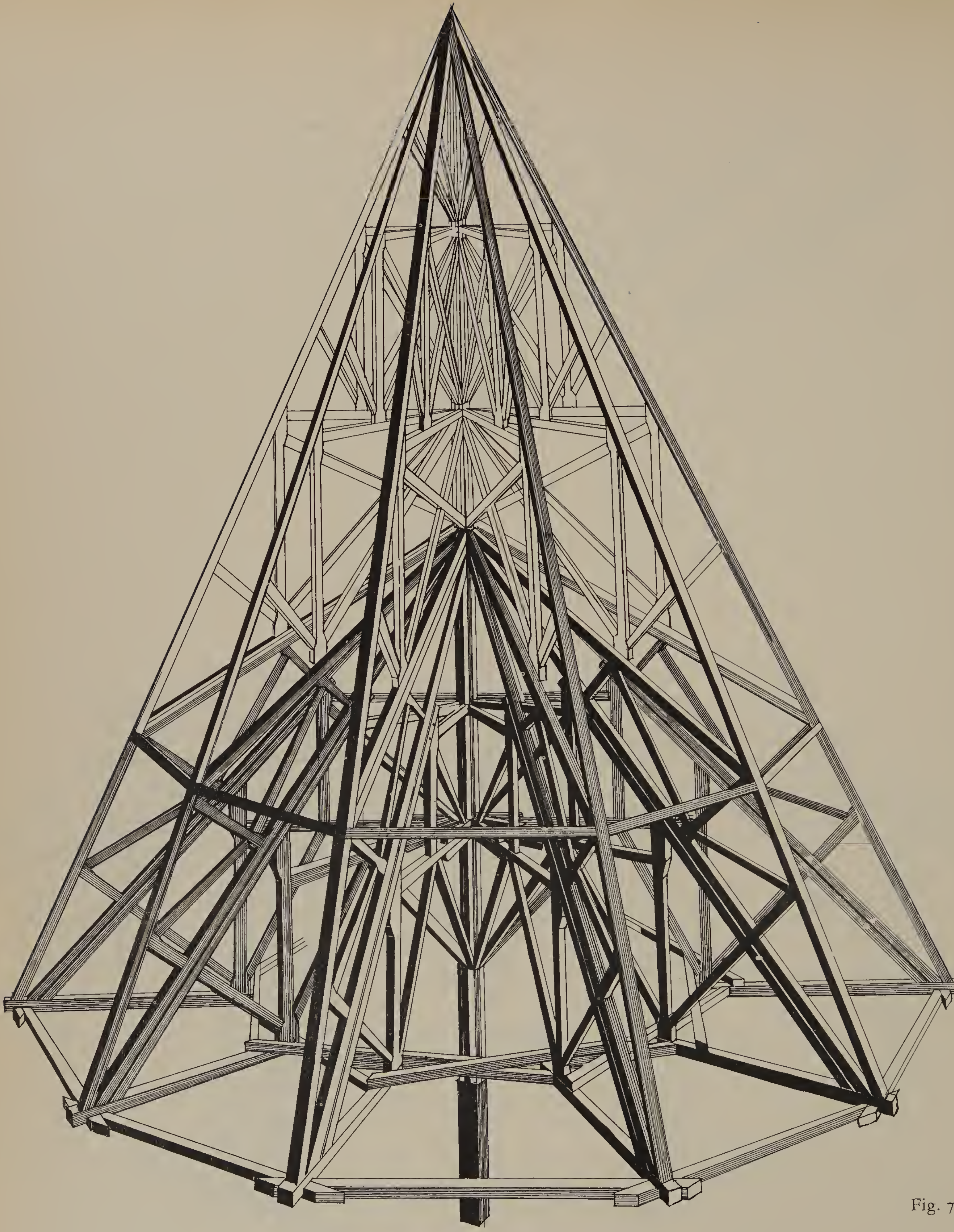


Fig. 71

1392, and these events are recorded in the Cellarer's Rolls at the Cathedral. The carpenter responsible was named Hugh and his fee was fifty-two shillings (£2.60) a year, plus twenty-six shillings (£1.30) for food. I am indebted to J. H. Harvey for this information.

The chapter house at Lincoln was designed by Alexander, and built between *c.*1220 and *c.*1235, according to J. H. Harvey.[55] This one is decagonal with prominent buttresses, and has an interesting roof in two "builds". The first is the "gambrel"-type decagonal structure that is heavily shaded in Fig. 71, and is believed to be by James Essex.[56] The second "build" is that which restored the roof to a fully pyramidal form, shown un-shaded in Fig. 71, and is believed to have been by Pearson and of *c.*1890. The lower part is of puzzling complexity and, although entirely of softwood and mainly assembled by ironwork and forelock-bolts, is the product of a master. Had better timber been available, it would have been assured of considerable durability. The pine used, however, is not capable of enduring the stresses to which it is subjected, particularly where it forms the radiating tie-beams that are much cut about to form their peripheral joints with the wall-plates. Why James Essex should have persisted in the use of forelock-bolts, long after threaded bolts with nuts had become available, is difficult to determine; but an aim for low costs could be the answer—since in terms of efficiency there may be little difference.

The basic unit of the design, visible when viewed on any one of its diameters, is of two superimposed queen-post assemblies set inside a pitched roof having a king-post. Of this the principal rafters are doubled, and a king-post truss with raking-struts mounted on the outer rafter—producing the two pitches of the "gambrel" roof. While this is a combination of two principles, the construction of the essential "ring-beam" that secures the inner ends of the ten radiating ties is possibly the architect's invention, and is so ingenious as to merit illustration (Fig. 72). The plan at the top of the drawing attempts to explain the method of its assembly; and the perspective underneath shows the assembly, in three dimensions, of the ties and the ten-pointed star formed by the beams. Words will no further clarify these drawings, which will be found intelligible if protractedly studied. The decagonal tie-beam so formed has proved, until this date, to be adequately strong although of pinewood, and is subjected to both radial extension and shearing stress. The wall-plates have also proved adequate, despite the fact of earlier examples known in lesser structures (parish-church spires) having been made in oak; but the tie-beams where they cross the crossings of those plates are likely to fail—mainly owing to the inadequacy of pine for such purposes.

The final example in this sequence is the chapter-house roof, another obtuse spire, of Southwell Minster. This is by Ewan Christian, who restored the Minster in 1868, the work continuing until at least 1886,[57] This is shown in Fig. 73, and is interesting in that it shows some advances on the possibly Essex design of the Lincoln example; notably, the strengthened corners of the wall-plates—similar to the angles of the Pershore apse roof. The built tie-beam and collars are reminiscent of the earlier work at York, but their span is less, being of forty-two feet. Five purlins were fitted into each facet of this roof and are not shown on the drawing.

The most spectacular work among the various polygonally planned cathedral structures is undoubtedly the lantern at Ely, which was built between 1328 and 1342, at a total cost of £24,061.34½—as the Sacrist's Rolls testify. No less than three master-carpenters are recorded as being involved in the work, each of them in supervisory capacities: Master Thomas, Master William de Houk and Master William Hurley—the King's Master-Carpenter. Other carpenters are recorded as boarded at the Prior's expense, together with numerous sawyers at various times during the long period of construction. The rolls also indicate clearly that the carpenters took over the huge scaffolding that had been used by the masons for the purpose of bringing the octagon up to its upper string-course in 1328, after which date the structural carpentry began. From this masonry octagon it is apparent that a specific design for the timber vault and lantern had existed and been understood by the master-mason, since the necessary sill-hooks and squinting-pockets had been worked into the ashlar at the correct situations for the receipt of the timber components. The carpenters therefore inherited a well-equipped site-operation, with "huge scaffolding" and a "great crane for lifting heavy weights", together with a stone carcase accurately built in accord with the same design—evidently the product of a "Medieval Architect", conversant with both masonry and carpentry. It seems unlikely that this genius should have been Alan of Walsingham, the Sacrist of Ely, but this is stated; and his portrait carved in stone was placed over the north-west arch of the octagon. Finally the lantern, which incorporated a belfry with peal of bells, was covered with lead as the Sacrist's roll for the twenty-sixth year of the reign of Edward III records.

In July 1757 James Essex the architect made a survey of the Cathedral in which he reported to the Dean and Chapter that the lantern, "being a work of the greatest importance, the neglect of it may be attended with y^{e} destruction of the church, and the loss of many lives: For whoever considers the magnitude and weight of this Tower with all its append-

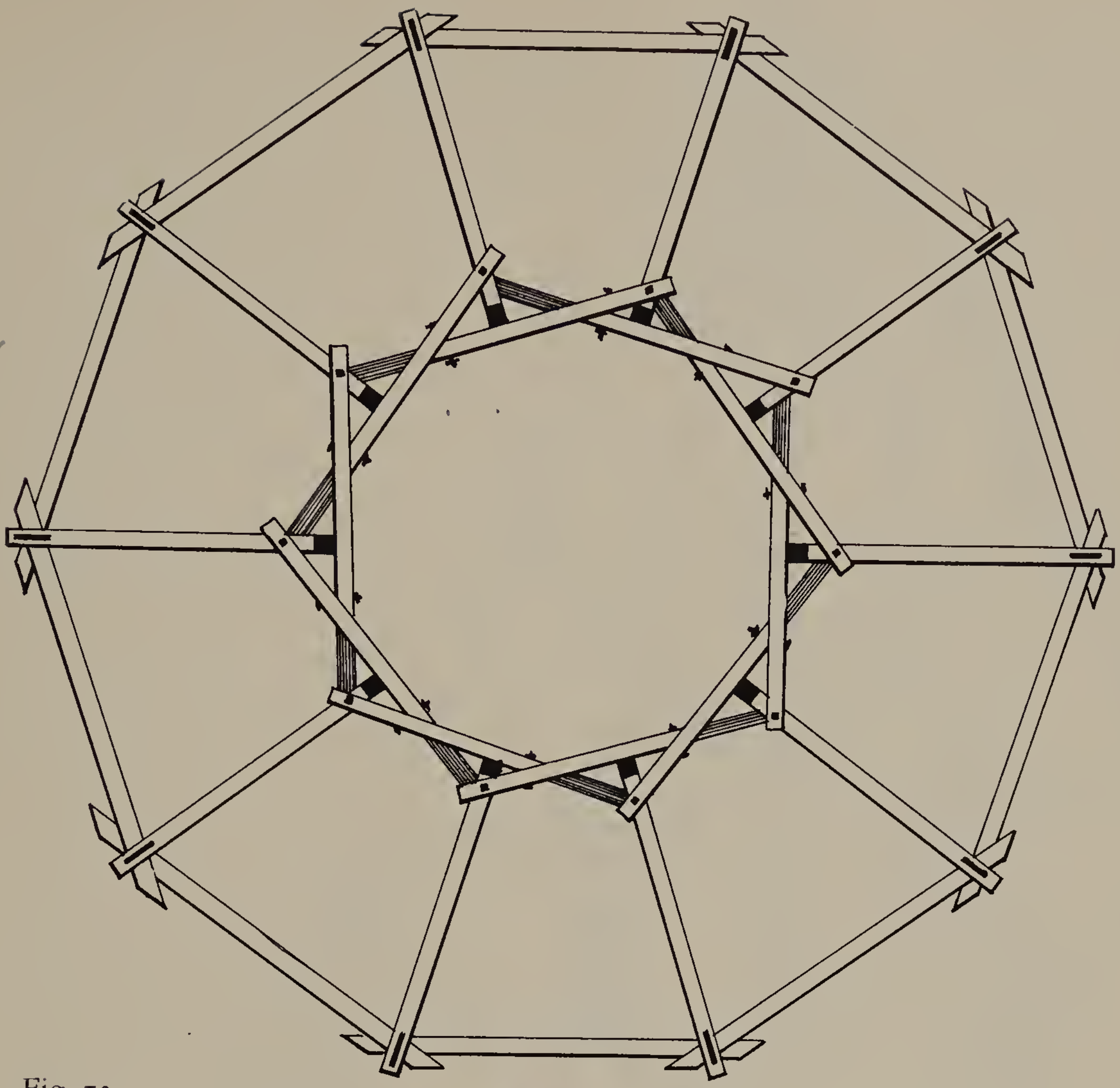
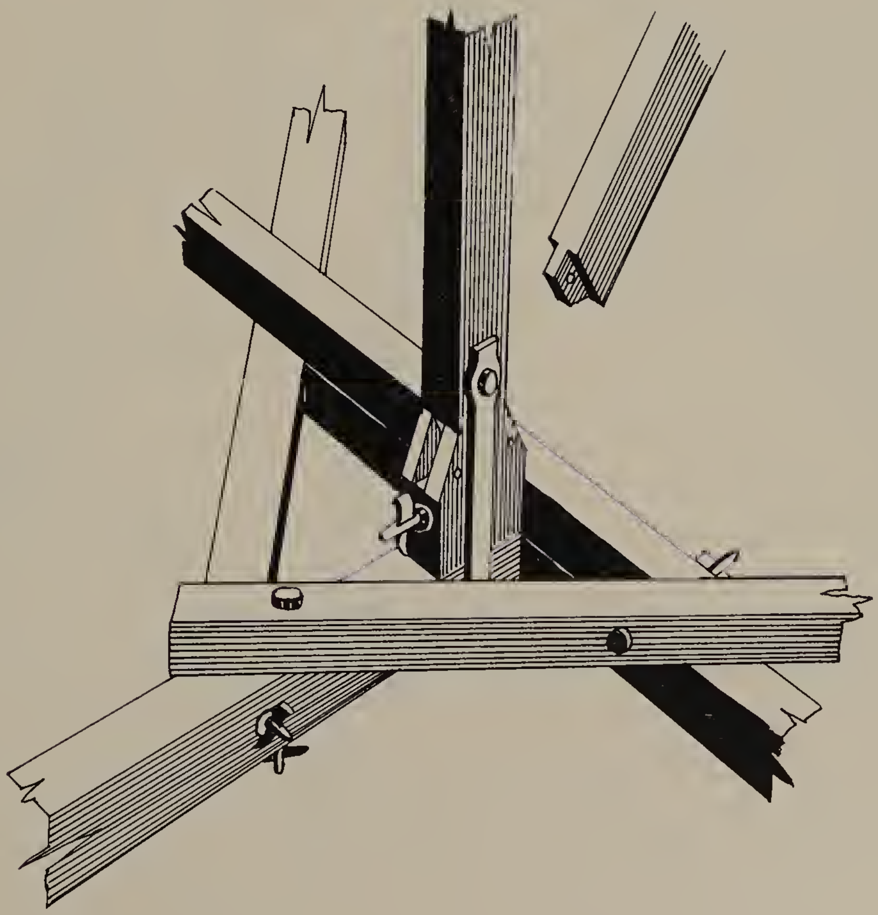


Fig. 72



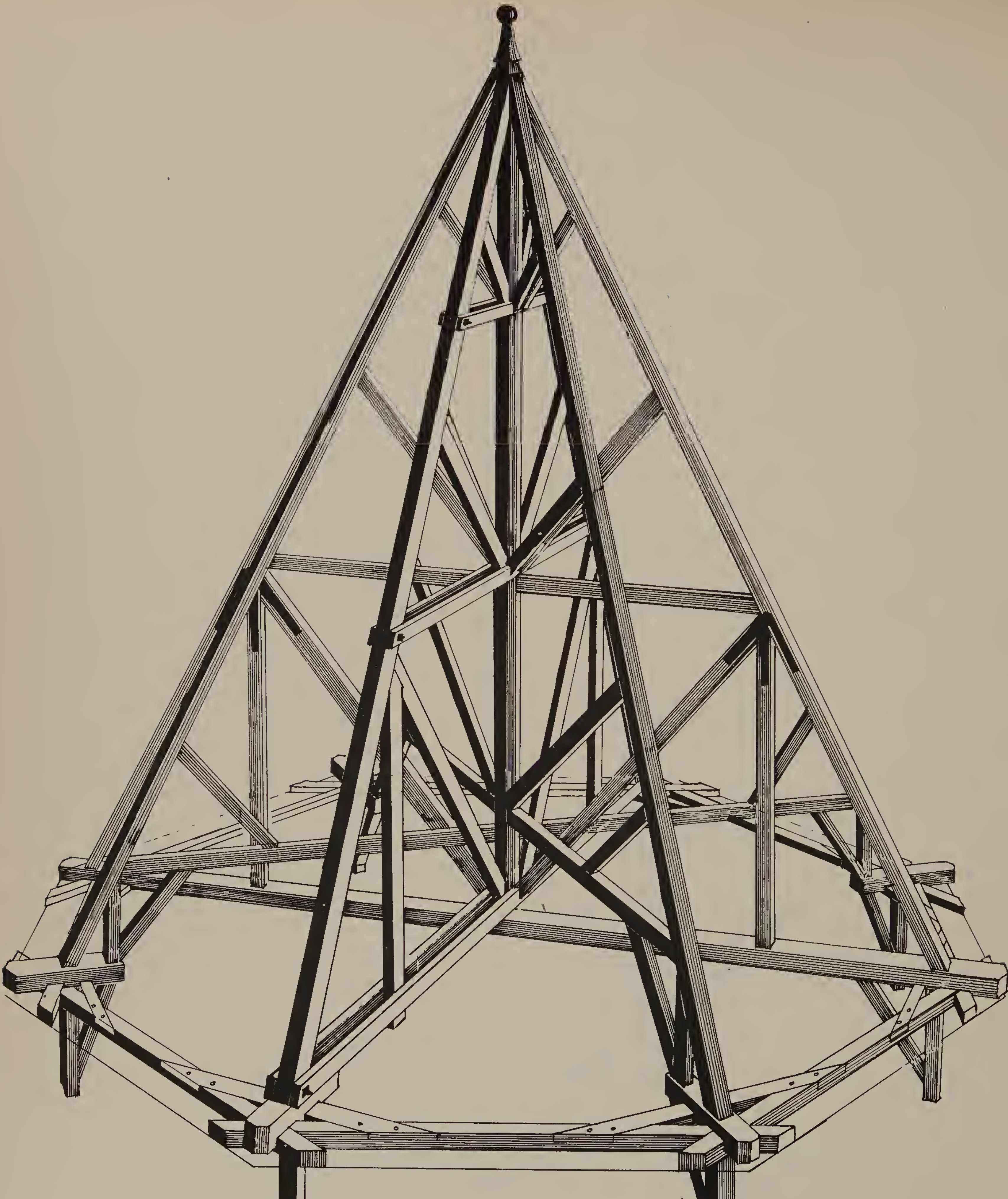


Fig. 73

ages, and the manner in which it is supported, must allow that the greatest care is required to preserve it in the state it ought to be". It is difficult to reconcile documentary evidence with actual structures, and in this case even more difficult to determine what repairs Essex really carried out, since in the same report he said: "The prodigious quantity of Timber and Lead of w^{ch} it is composed was at first supported by sixteen pieces of Timber only of w^{ch} number 7 or 8 are *now rotten* and unfit for supports, so that the whole weight is now unequally supported by those that remain sound." He concludes his report in so far as the lantern is concerned with the remark that "altho' this ought to be the first part that has a general repair, the other part ought not to be entirely neglected for care sho^{d} be taken in time to prevent any mischief by securing them for the present and at a more convenient opportunity to repair them effectually". My own notes give no indication that Essex, or any other architect, did replace any of the sixteen shores which carry the lantern, since all of them appear to have a uniform age and patination. What he probably did was add the very large quantity of relatively small-timber trussing that now fills the space around the lantern's first and internal storey. All of this subsequent timberwork is omitted from the illustrations as irrelevant. It is, in fact, difficult at the present time to determine the original design of the structure, since this has not been retained; the architects who have been successively responsible for it have added structures to it, and accurately worked sockets in the masonry are the only clear evidence as to the absence of a large number of very big timbers.

The method originally used to construct the lantern must be conjectured and necessitates an interpretation of the documentary evidence, which in itself does not agree with the structural evidence since the Sacrist's Rolls indicate that the fifteenth year of the work was devoted to the construction of the wooden vault beneath the lantern and the structure itself shows that the vault was complete, with all its 104 timber ribs and the "cobweb" of flooring that surrounds the central octagonal void, before the "exaltatione magnarum postium in novo choro"—which seems to indicate the raising into position of the huge corner-posts. Fig. 74 shows the general arrangement of the ribs, which could not be set in position without the floor, into which each rib is chase-tenoned. The floor, with the ribs framed in, is shown in Fig. 75, which also shows the eight posts originally set into grooves running the full height of the stone octagon's corners and the lesser posts that were framed into the apexes of each of the eight arches. The scaffold was inherited from the masons and sill-hooks of stone were previously in position in the masonry, and it was possible to set four sides of the eight-sided

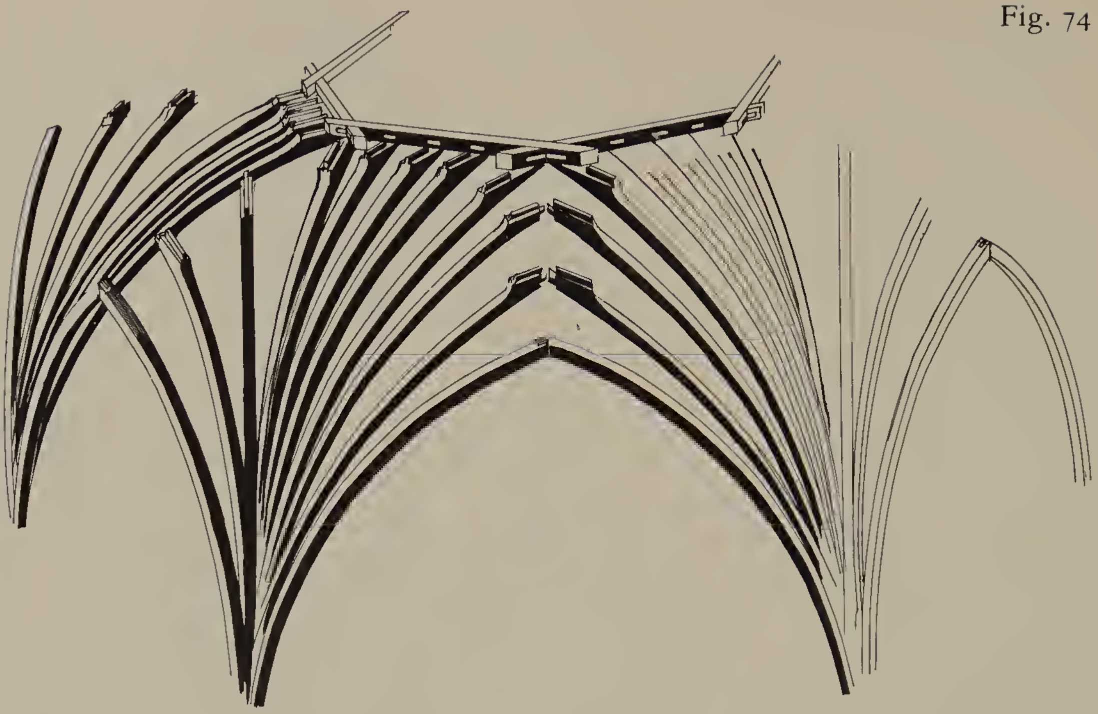


Fig. 74

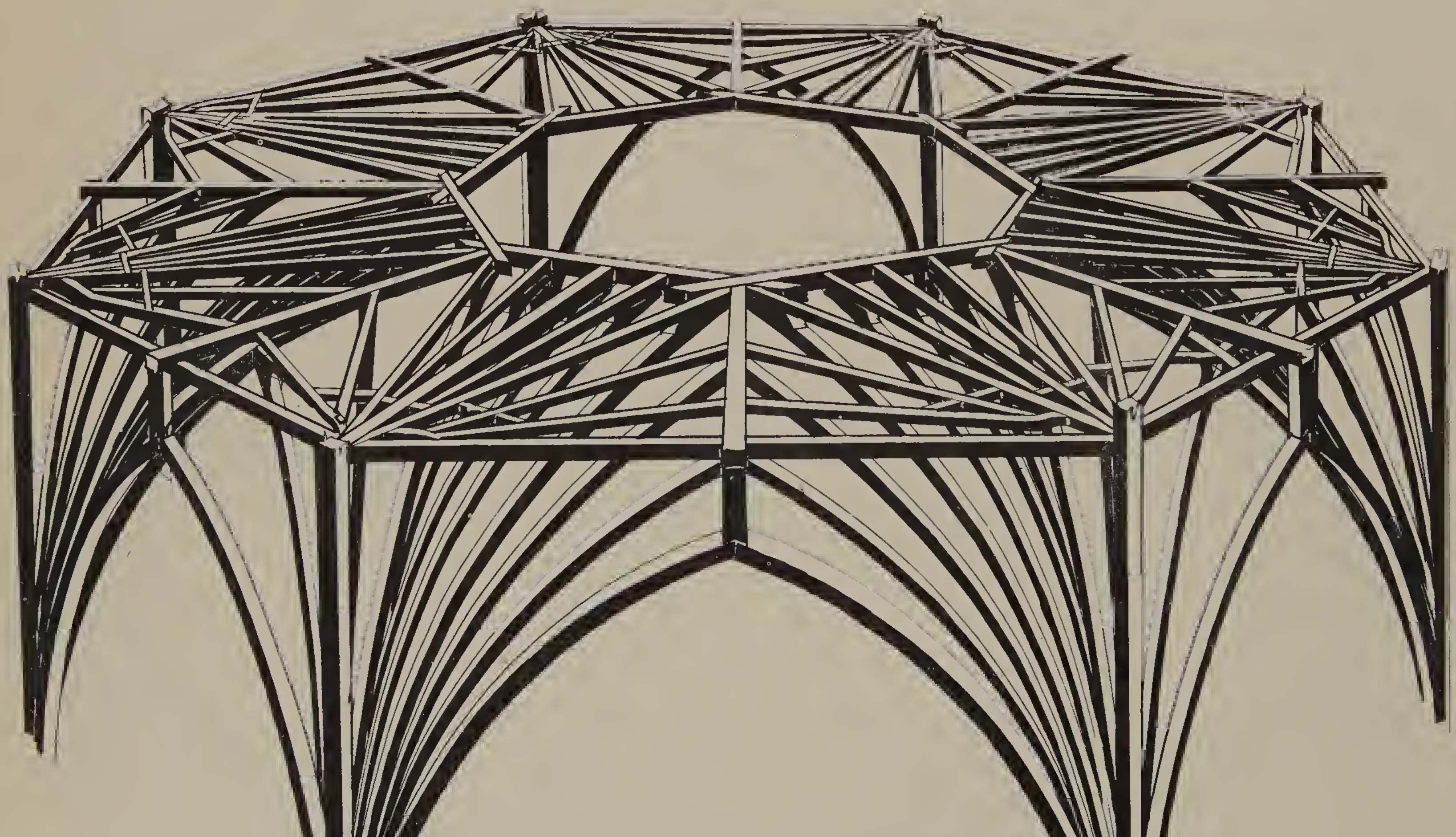


Fig. 75

Fig. 76

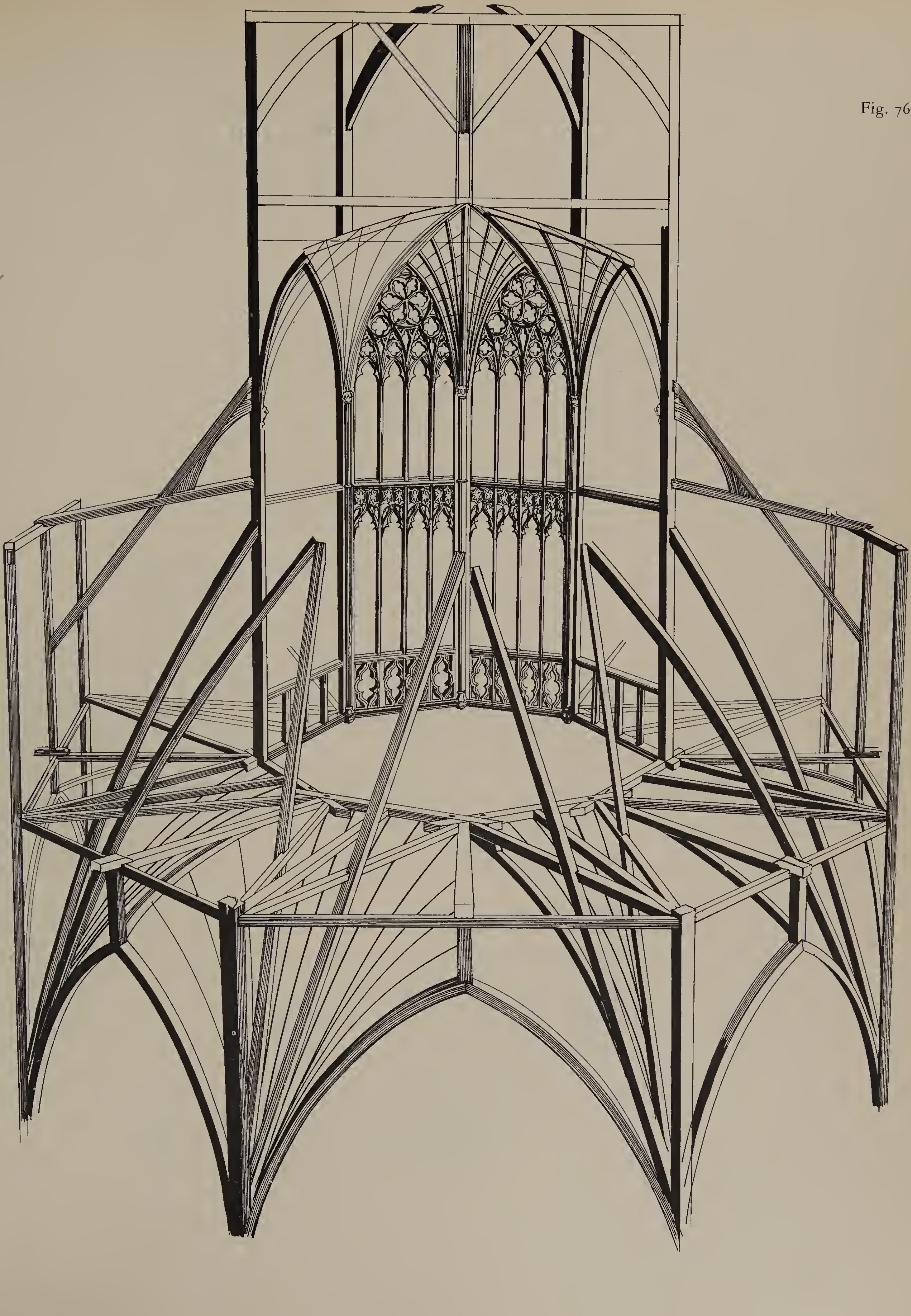


Fig. 78

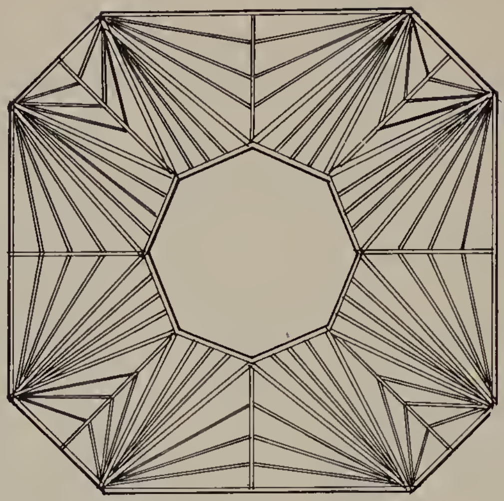
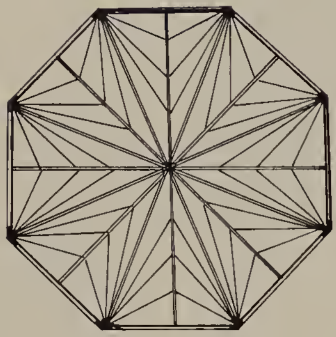


Fig. 79



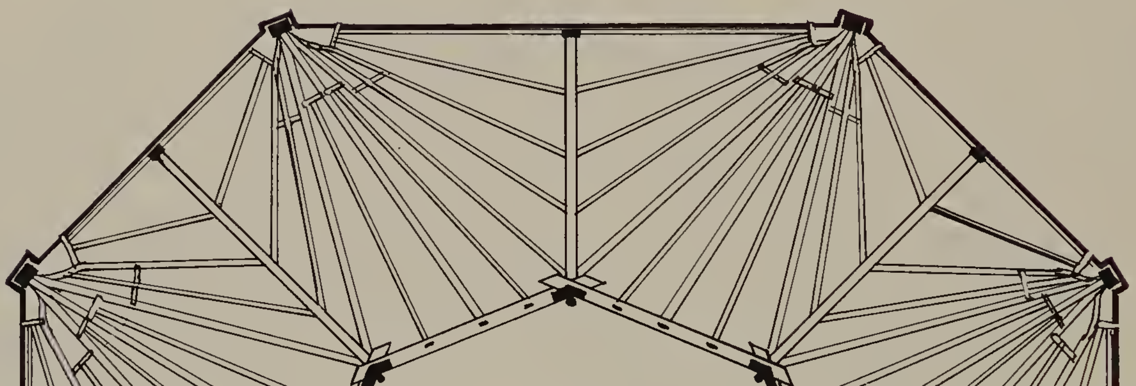


Fig. 77

"ring-beam" in position, each having a triangular side-elevation. The radiating beams run from the centre of each side of the "ring-beam" and are tenoned into the angle-posts set into the stone grooves, and those in turn were strained apart by the octagon of rim-timbers surrounding the floor, which was additionally secured by the stone sill-hooks. The other four sides of the structure could then be added, and the cross-halved joints at the ring-beam's corners indicate the precise sequence followed; eight pendentives of timber were thus positioned, and when all were assembled the whole was immensely strong.

The lantern was built on this perforated platform, the tenons at the feet of the great corner-posts penetrating both timbers forming the ring-beam angles. The raking-shores were apparently set in place before the posts were erected and were there to steady them as soon as reared. The great posts are generally stated to be sixty-three feet long (I have not measured their lengths), and in one piece. This is not entirely true; one post is scarfed throughout a great part of its height and secured with a free tenon and pegs every yard, while others have extensions scarfed on at their tops. Notwithstanding this, they are enormous posts and came from "Chikissand" in Bedfordshire, whither Walsingham went with Master Thomas and purchased twenty oaks for nine pounds during the building period.

The Sacrist's entry for the fifteenth year probably refers to the planking of the vault, the fitting of its bosses in some cases, and the painting of its archivolt. The whole structure, vastly simplified by deleting huge quantities of timbers, is shown in Fig. 76, in which the pinnacles surmounting the lantern are also omitted. Fig. 77 shows the floor at the lantern's base, and Fig. 78 shows the pattern formed by the 104 vault-ribs beneath it, while Fig. 79 gives the pattern of the highest vault beneath the belfry floor—of which the central boss was cut by John of Burwell in 1337–9 and which is situated 152 feet 6 inches above the floor.

6 CATHEDRAL DOORS

The west doorway at Selby Abbey is ascribed to 1170 at the latest, and is still hung with a pair of wooden doors that may be of the same age.[58] The rear, or inside, of the left-hand half of these is illustrated in Fig. 80. They are framed in portcullis fashion, having squarely crossed ledging on both faces and their planks apparently being sandwiched between these two assemblies. The inner framing is notch lap-jointed all round its edges, and every crossing-joint is transfixed with an iron clench riveted over a square rove on the inside face. Some late examples of the use of these joints are known—particularly as a result of the present study—but the possibility that the inner frame, at least, of the Selby doors is of the late twelfth century is worth investigating. Among all the doors examined only four are built with notched laps and all are undoubtedly early, the latest being the treasury door at Westminster, ascribed to AD 1303, 1304 or 1305 (not illustrated).

The Norman gateway forming the main entrance to Peterborough Cathedral precinct was built by Abbot Benedict (1177–94) and retains the greater part of what appear to be its original doors.[59] One is shown in Fig. 81. They are much worn and have had the lower parts replaced, but their rear frames are notch-lapped round the edges as in the Selby example. Their frontal planking appears to be a renewal, of the Perpendicular period. The actual "hanging" of these has also been altered, and it seems that the harr-timbers, the vertical members of doors nearest their hinging, originally formed the pivots or mounted an iron pivot. This may be a unique example in the present context. This is shown in the diagram (81).

The pair of doors with central shuts illustrated in Fig. 82 give access to the cloisters at Durham. They therefore pertain to the Cathedral itself since the cloisters are dated later, to between 1390 and 1418.[60] Doors constructed in this manner are extremely rare and the only other examples as yet known are those of the parish church at Eastwood in Essex.[61] The principle was to assemble planks, in this case four, with rebated edges—these are shown at the lower right of the drawing—and then drive tapering semi-circularly sectioned ledges into dovetail-sectioned housings, previously routed into their rear faces. These ledges, of course, became increasingly tight as they were driven, and produced what has proved

Fig. 80

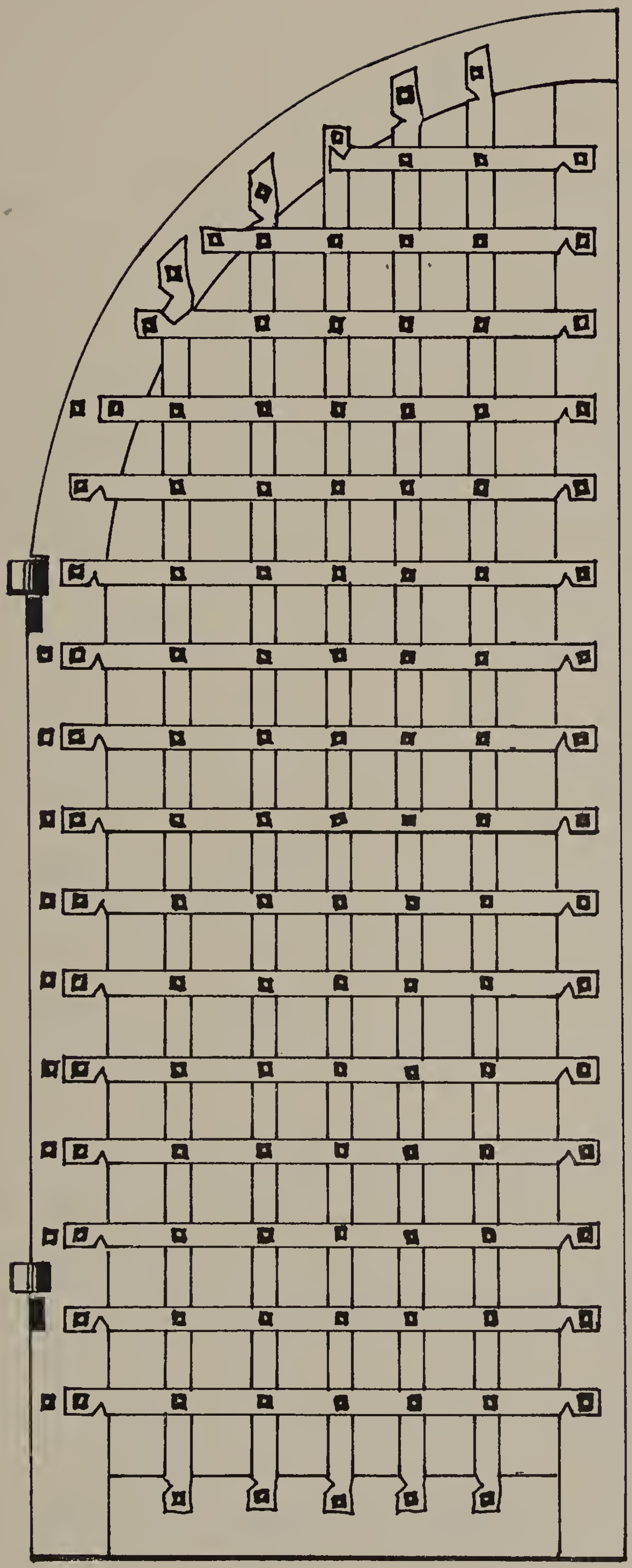
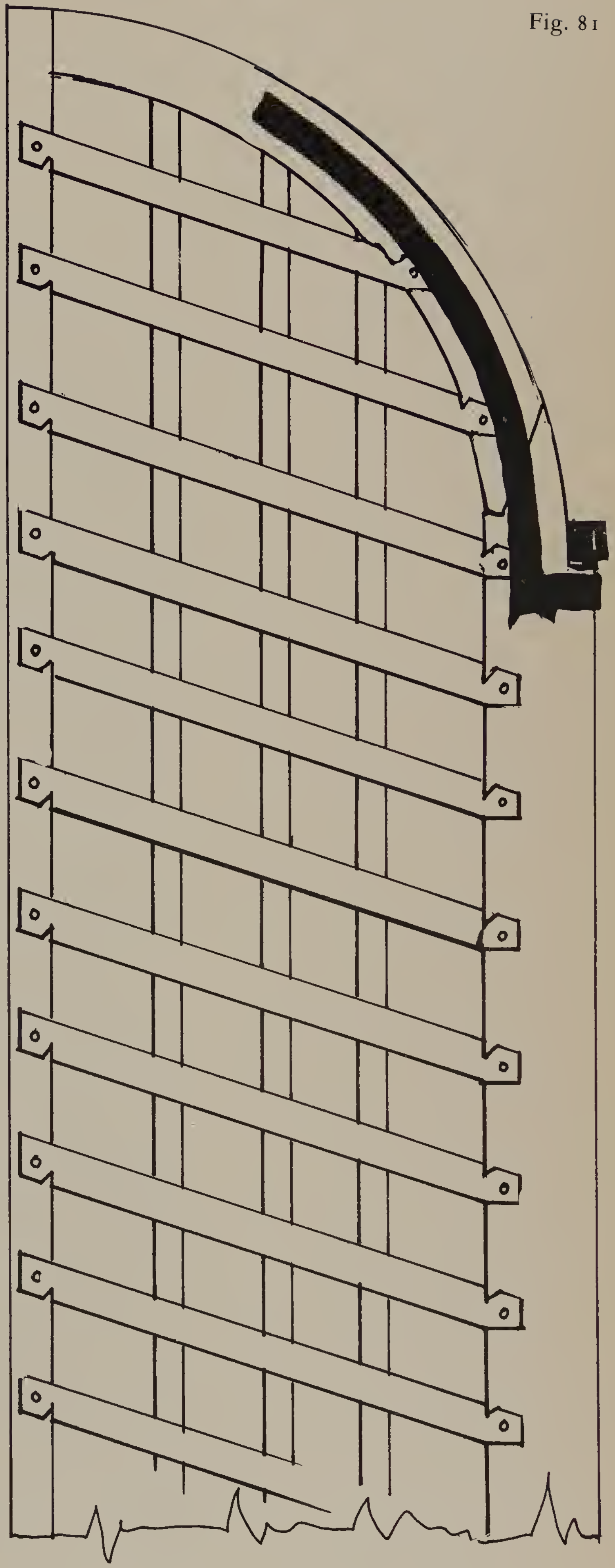


Fig. 81



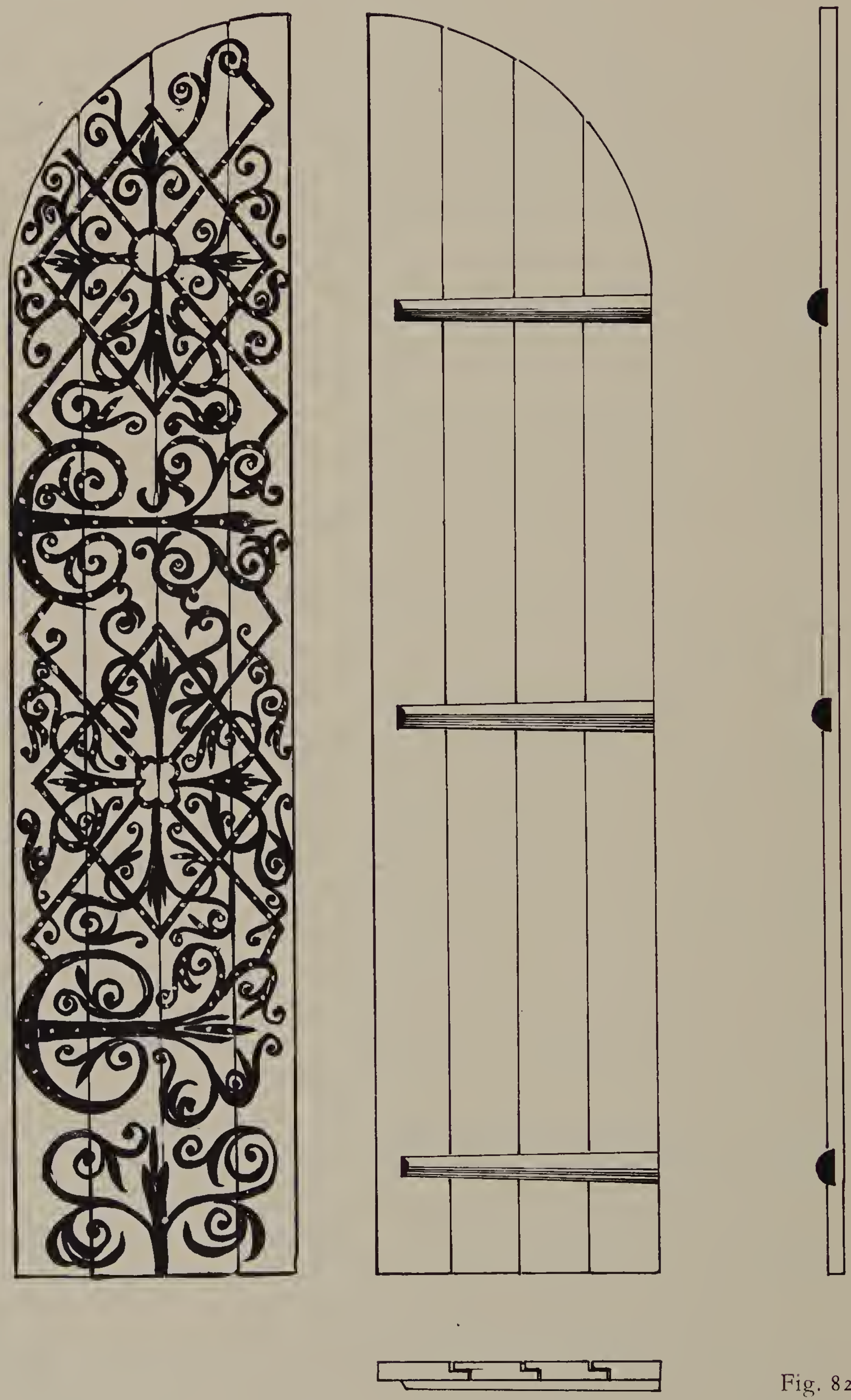
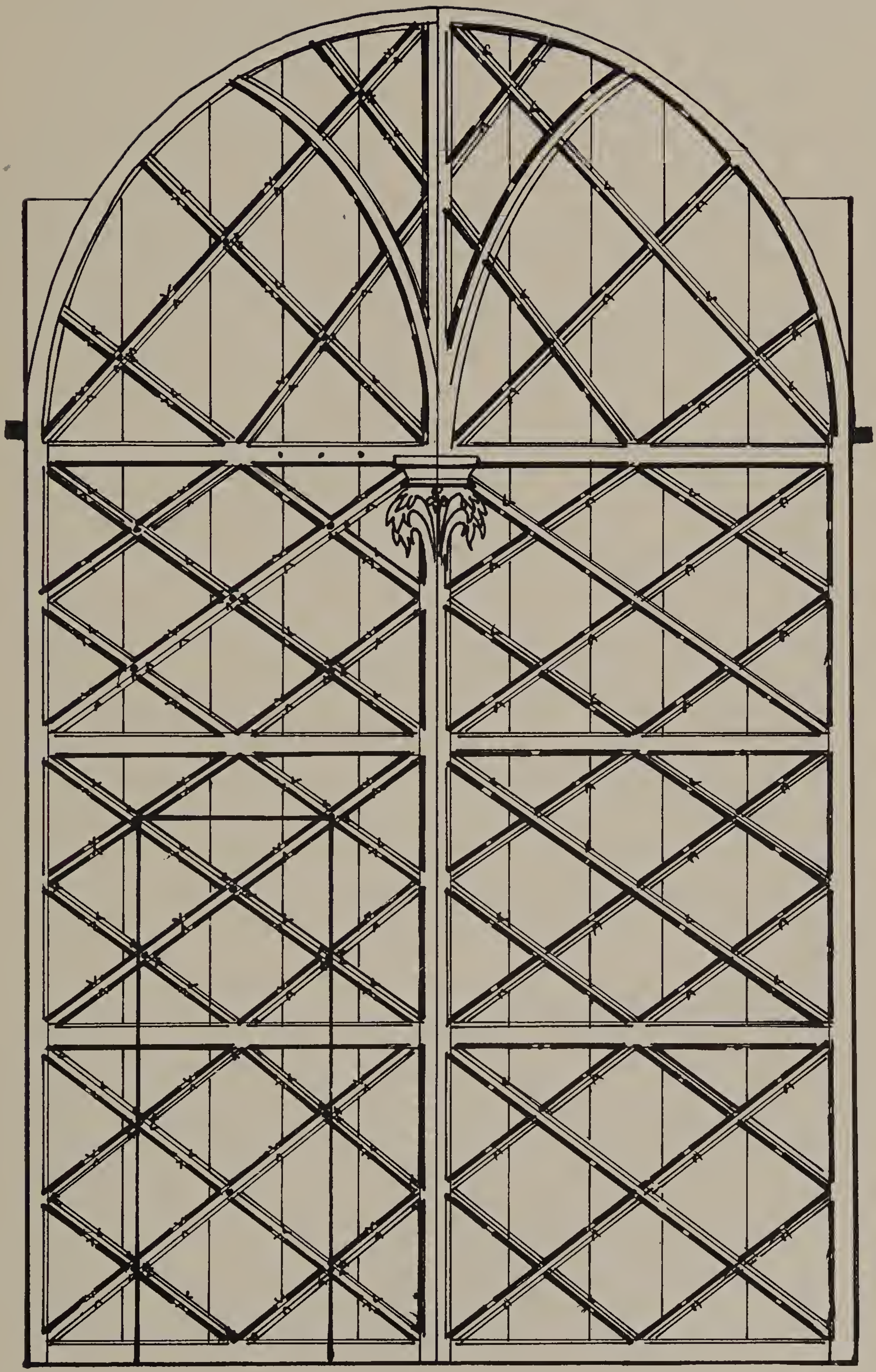


Fig. 82

Fig. 83



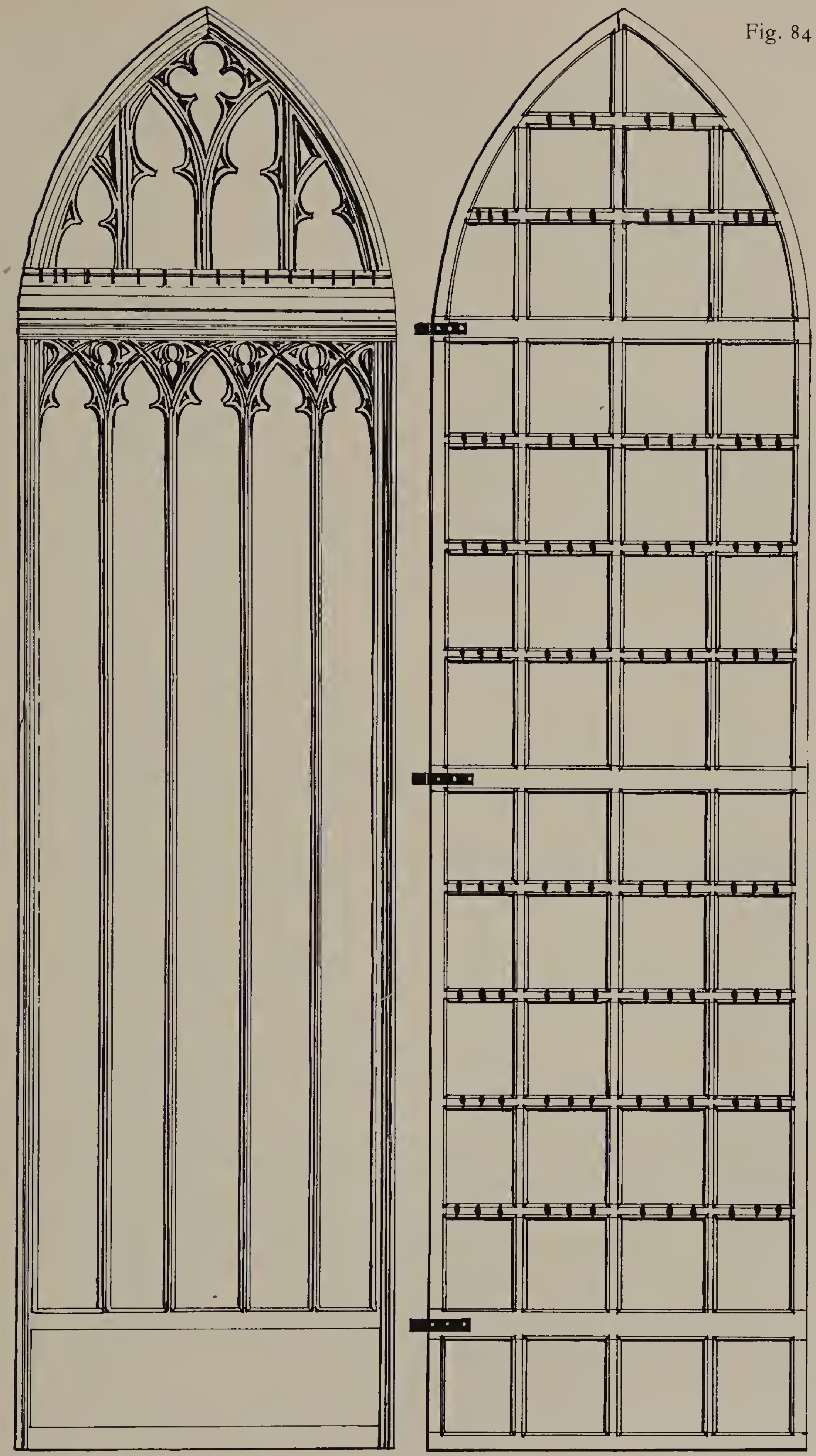
to be a very durable assembly. A vertical section is also given at the right-hand side of the drawing. The rich wrought ironwork applied to the inner face of these doors is likely to be of the same age since it materially strengthens the whole, and a dating contemporary with the nave, during the twelfth century, is probable.

Fig. 83 shows the interior face of the central west doors of Peterborough Cathedral, which are datable to the same protracted period of time as the west front there, *c.*1193 to 1230.[62] The use of dog-tooth ornament on the diagonal ledging indicates a date toward the end of the given period, as does the naturalistic carving on the shuts timbers of foliage below an abacus. The choice of saltire-bracing for the ledges is probably an association with the dedication of this church.

Wells Cathedral has a great number of doors which are datable to the masonry of the doorways they fill, and of these the tall lancet-shaped pair giving access from the northern porch are illustrated (Fig. 84): a front and a back surface are shown. The back or inner surface with its crossed ledges is most interesting in that the elongated type of "roves", which are wrapped round the chamfered timbers, closely resemble early shipwrights' technique as used to "strake", or plank, clinker-built vessels. This form of the rove was intended to prevent the usually slender timber from splitting, as it was most likely to do, when the "clenches" were hammered over the "roves". The Anglo-Saxon door of St. Botolph's Church at Hadstock in Essex[63] shows this same technique at a more pronounced, and clearly recognisable, stage; and it can moreover be traced through numerous doors of later dates, ending in the use of lozenge-shaped roves that had apparently forgotten their origins. The Wells doors under discussion are dated to *c.*1208,[64] and this is very acceptable for their rear framing, but there seems some possibility for their having been re-faced—in the manner shown to the left of the drawing.

The pair of doors shown in Fig. 85 are the west doors at Ely. These are included because they are the only example of the counter-rebated technique, which is known to have flourished during the late twelfth century,[65] and which in this case indicates that the planks have been re-used during the Early English period. The ledging is again in diagonal or saltire patterns; and the edge-members seem original to the second use of the planks and ledges. The bar, shown in its horizontal "locked" position, is also of that period; the outer surfaces of these were re-faced apparently by Wren, whose initials are set into their decorative ironwork. The manner in which such counter-rebated planks lock together is shown in the diagram at the right of the illustration. The door or doors

Fig. 84



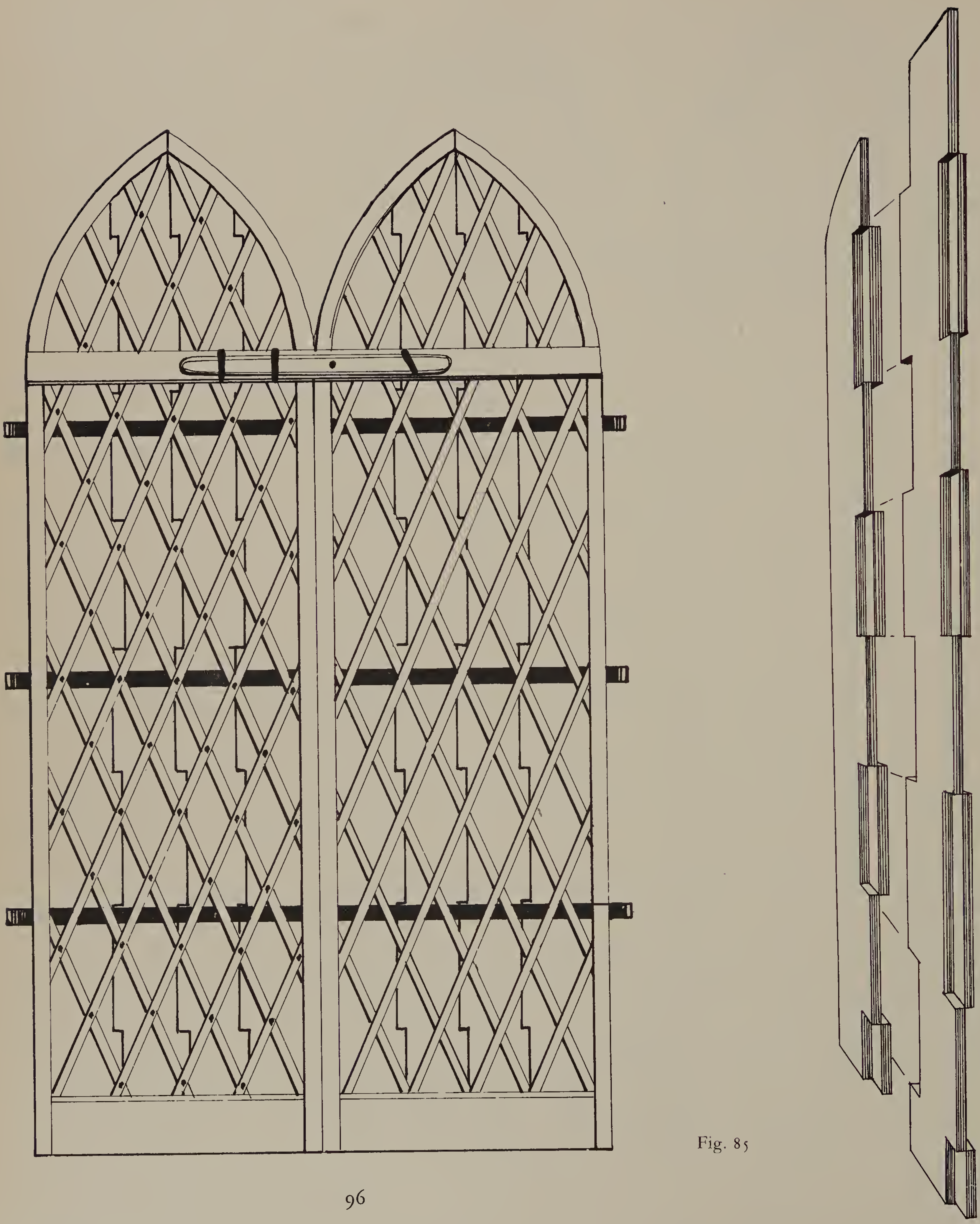


Fig. 85

from which these two were made was probably of a date contemporary with the west transept at Ely, *c.* 1174–97, and their conversion into Early English style doors could have been at the time of adding the Galilee porch to which they relate *c.* 1250.

The door of which both faces are shown in Fig. 86 is one of double ones which ensured the security of the Wells chapter-house crypt and treasury, which is dated to between *c.*1250 and 1286. The rear framing is similar to that used on the northern doors already shown, while the naturalistic ironwork merits much praise and would seem to relate to the Early English taste in decorative detail.

The fine pair of doors shown in Fig. 87 are those giving access to the cloisters at Lincoln, and it has to be determined whether they date from the east choir transept there or the cloisters themselves. The transept was completed by 1200 and the cloisters by 1295. The last date would seem to be the most applicable to the style of ironwork on the doors. The section of the frame members on the rear face of this example is channelled, and

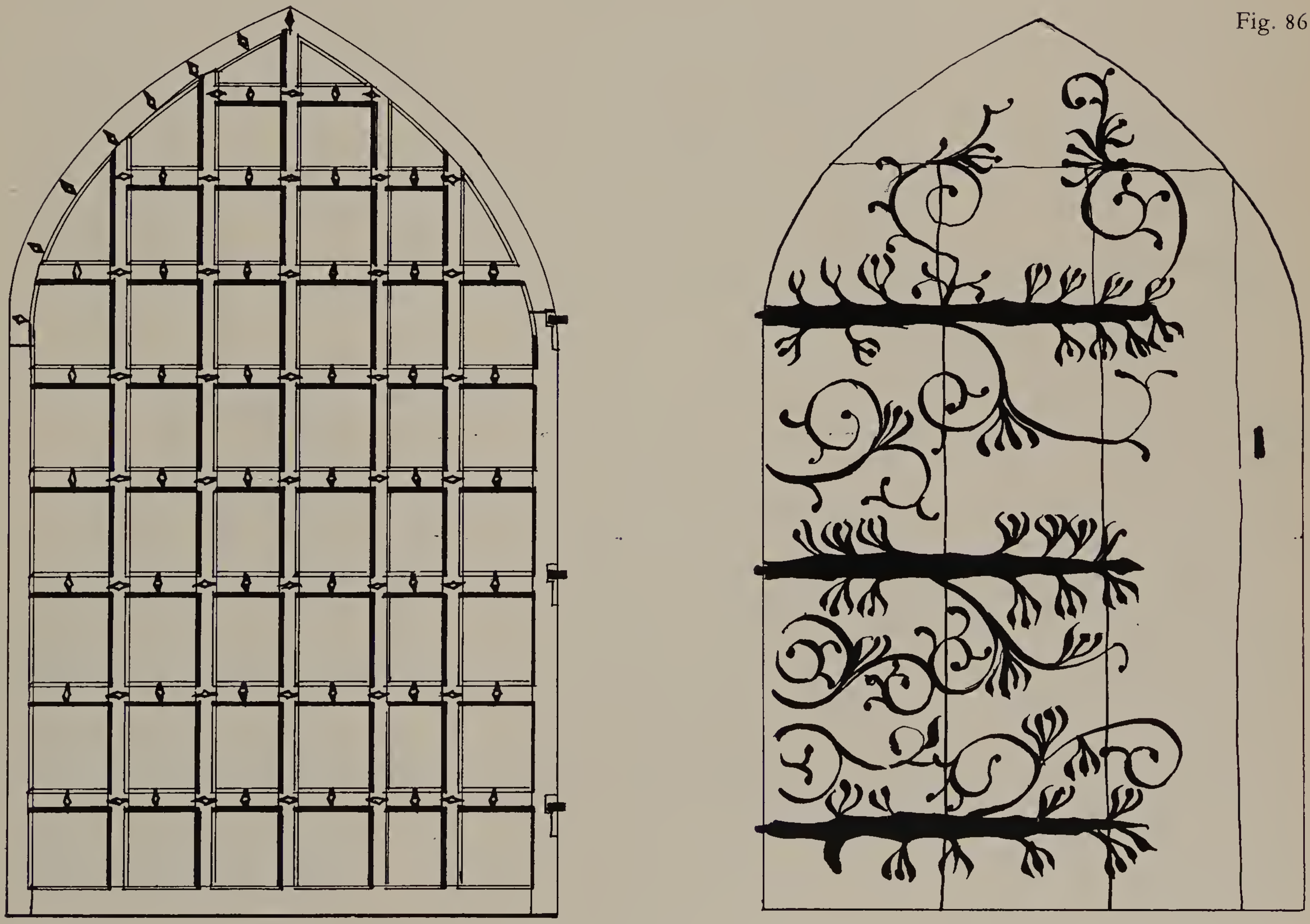


Fig. 86

the spikes are seated in the channel; their corners are chamfered. The next doors, from Southwell Minster, are included because they conform to the generally accepted views upon the dating of tracery styles, in this case the reticulated ogee design, with quatrefoils in each space. A probable date for these would be during the second quarter of the fourteenth century. They are shown, both faces, in Fig. 88, and their rear framing is severely economical in contrast to the rich texture of the outer faces. They were made of the Norman shape, in order to fit a pre-existing doorway. The example given as Fig. 89 is the cloister door from St. Albans, and known as the Abbot's Door. It is worth stressing that this drawing shows the back or outer face, which is a very fine example of pierced planking with chamfered saltire ledging; it is ascribed to the times of Abbot de la Mare and dated to AD 1360. The frontal face is decorated with blind and deeply carved tracery on a larger scale, and the whole is in an excellent state of preservation.

The Hereford cloister-door shown in Fig. 90 came from the centre of a stone screen formerly beneath the western arch of the tower; it was removed in 1840 and is dated to the late fourteenth century.[66] The construction is of crossed planks secured by spikes having re-driven points, to which the blind tracery is applied. The profiles given in black are those of the edge-timbers and muntins of the design. Contemporary doors lead into the cloisters of Gloucester Cathedral, which were built between c.1370 and 1412; these are illustrated in Fig. 91, which shows both faces. They are today painted on the traceried face, in red, green, and gold for the fillets. Their ironwork is inset and is flush with the timber surface.

Fig. 87

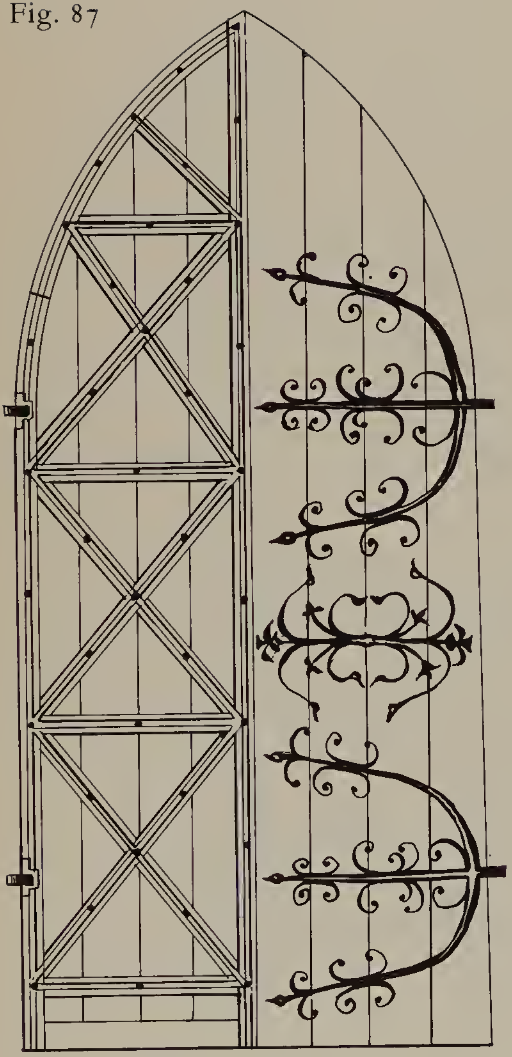


Fig. 88

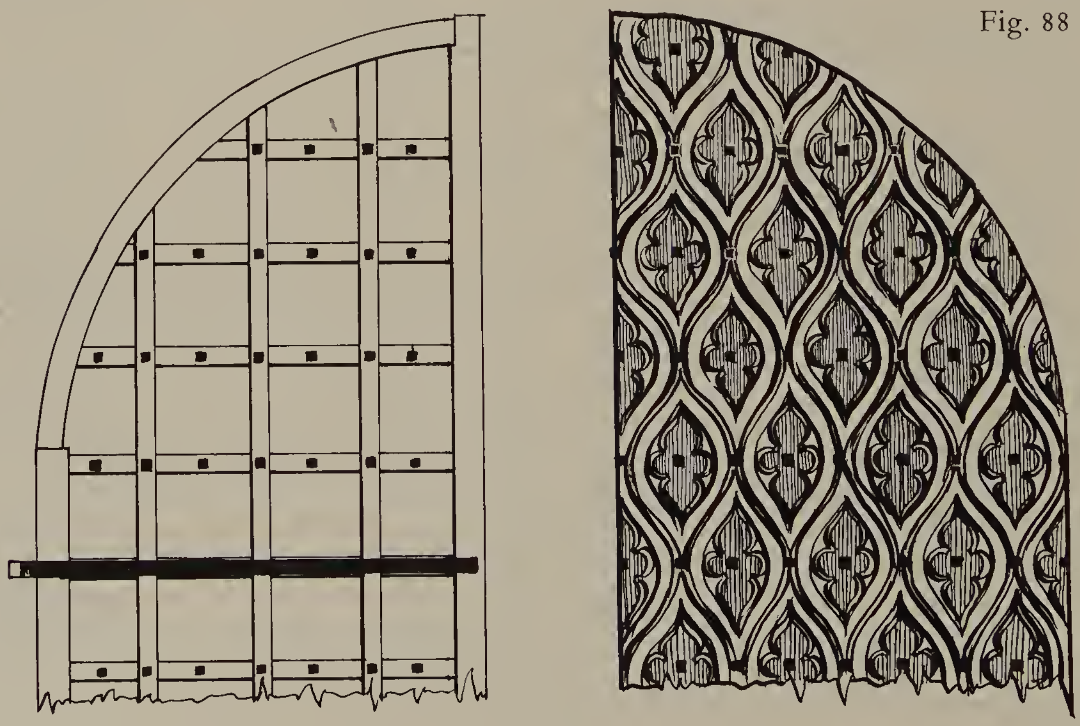
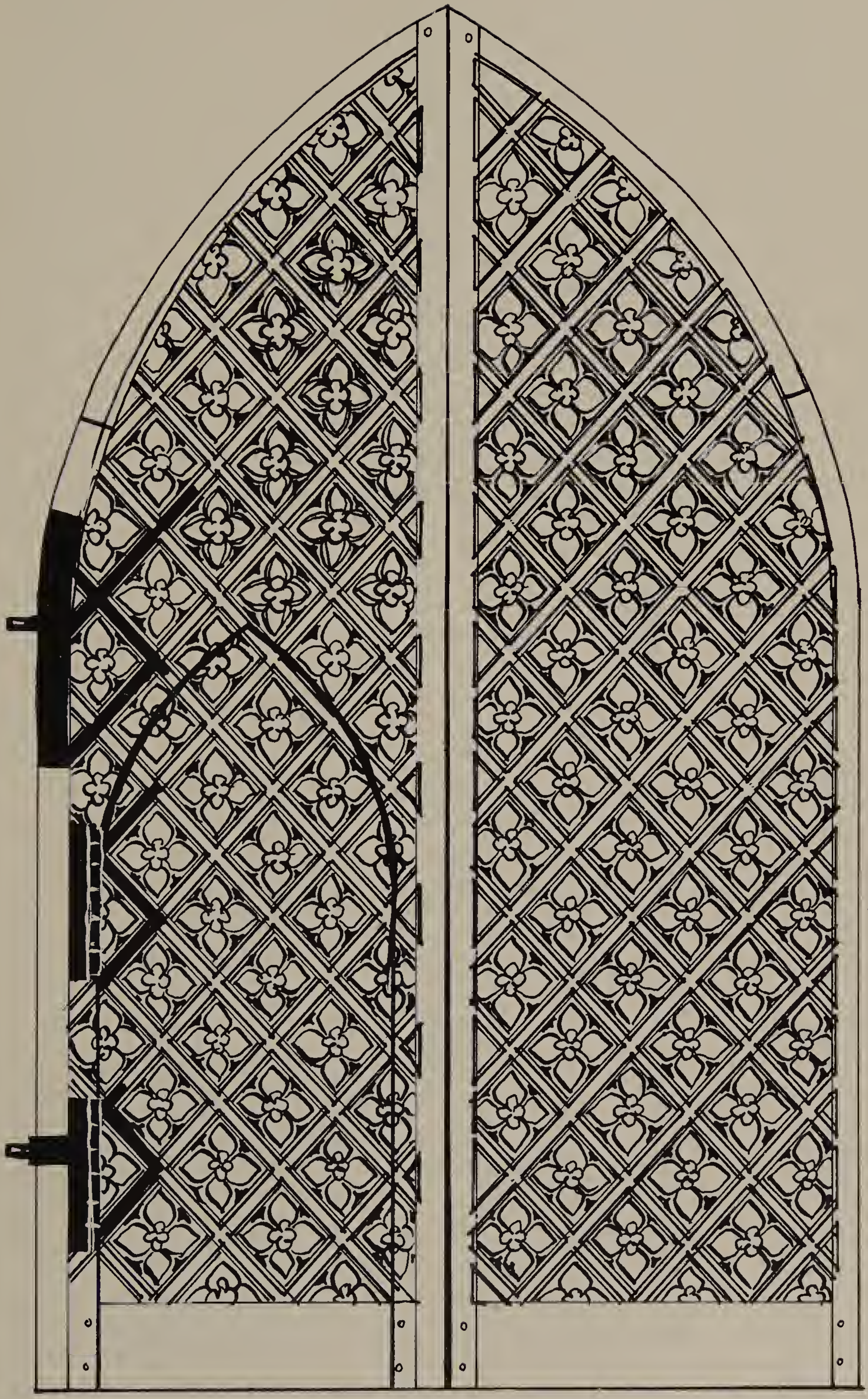


Fig. 89



The larger of the two pairs of doors at the Norwich precinct, which give access to the St Martin's Palace, shown in Fig. 92, are in my opinion the finest of their kind, since their profusion of traceried richness is wholly successful aesthetically—which was not always true of the later Perpendicular designs. It is noticeable in the majority of doors of this period that the richness of carving lavished on their frontal faces is in clear contrast to the poverty of framing on the rear faces. This example is formed of heavy plank, in a double laminate within a securely jointed surround, of which the only weakness was due to shrinkage of the inadequately seasoned timber. These doors were dated to between the years 1461 and 1483 by J. A. Repton,[67] and were finished with lozenge-roves, such as previously described, continued as a decorative form after losing their original purpose. Finally, with the west doors of Westminster Abbey a distinctly eighteenth-century style appears which derived in all probability from purely secular building practice. One of these doors is shown in Fig. 93; they are not precisely dated, but I under-

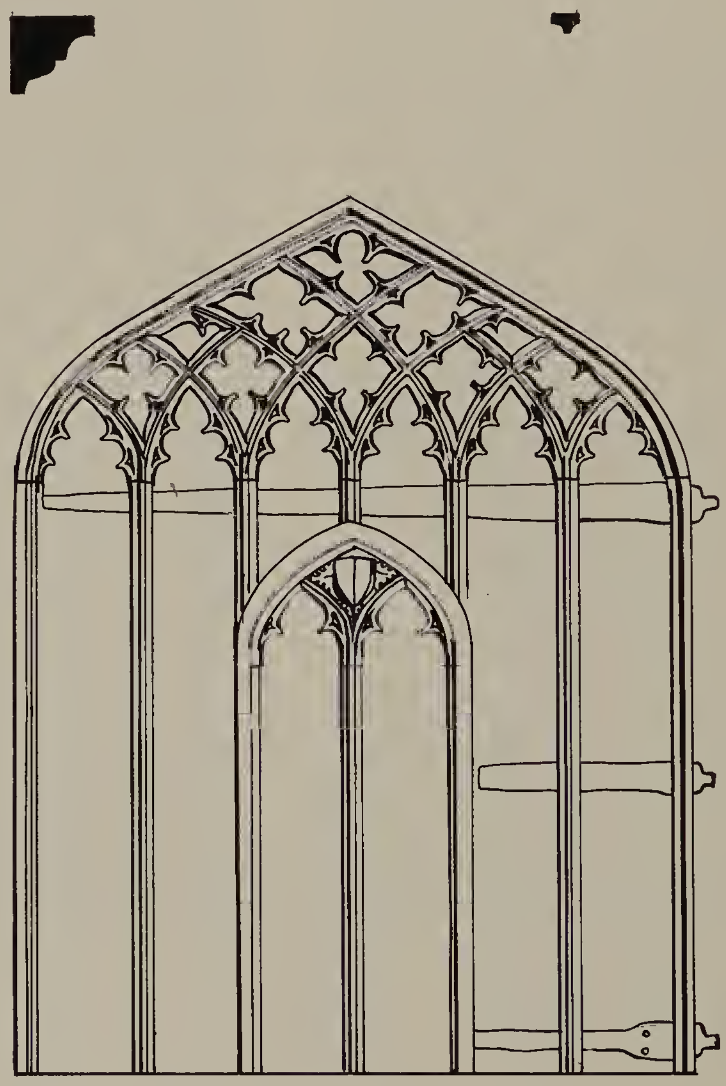


Fig. 90

stand that they were probably made a little before 1700.[68] They have truly fielded panels that are set in rebates on the edge thicknesses of the framing, excellently made, and with complex shutting-edges, in oak. Comparable doors of less size, which perform the lesser function of gates, exist in the north porch at Wells.

As in the cases of both ridged and lean-to roofing in cathedrals no single type-series results from cataloguing the evidence, but it seems likely that if the vast and necessarily unknown loss of examples, due to both deliberate and accidental destruction during the passage of the centuries, could be included in the evidence some pattern might emerge that was intelligible. Or, more probably, a type series that proliferated as it progressed through time, having off-shoots from the main stem of development, itself complying with the basic principles of design—fitness for purpose, suitability of materials and economy of means. So far as the doors listed are concerned, no archetypical door is among their number; and it is apparent that what seem the oldest two cases are part

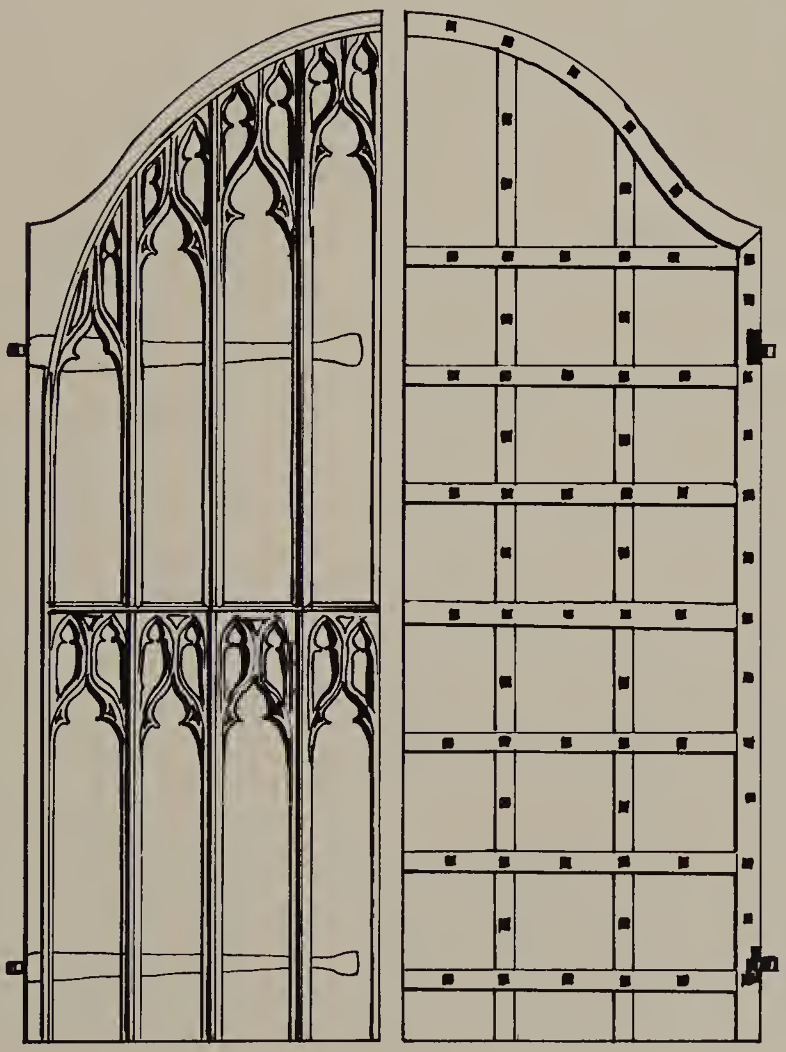
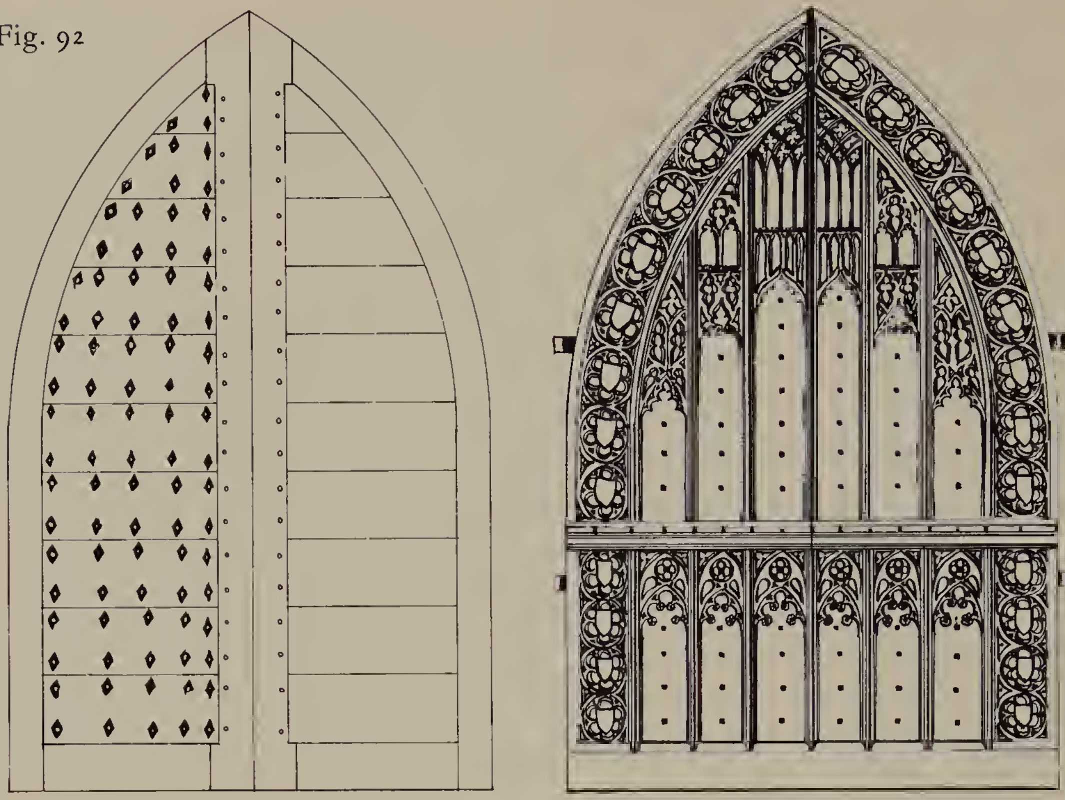


Fig. 91

Fig. 92



of a succession of doors built on the same principles that extends from the late twelfth century into the sixteenth century. This type had a cross-ledged frame to which planking was applied, and during its long period of usage variations were necessarily confined to the form of its jointing, both of frame-members and of plank-edges. Such changes included the use of notched lap-joints, dovetailed lap-joints and penetrative tenons, each of which will be found to have periods of popularity with the craftsmen involved. The edge-jointing of the planks applied to these frames gave equal scope to the inventive craftsman, and a succession is traceable from square-edges, through rebates and splayed rebates, V-edging and back to square-edges in a laminate of planks transfixed by clenches. During the course of these developments someone invented the counter-rebated edge, which was widely exploited by the Normans it seems, since numerous examples that survive are datable to the end of the twelfth century.[69] One example of this is the re-used planking of the Galilee doors at Ely. It is also apparent that examples of these techniques found among the totality of survivals are not likely to indicate the dates of such developments as they incorporate, since only very rare examples can be shown to be the novelties of their type and times. It is equally apparent that eclectics had little to choose from until invention had produced variety, and that thereafter cost-effectiveness controlled the early craftsmen much as it does those of our own times.

The counter-rebated planking exploited in the Norman period was an invention that enabled the craftsman to produce an adequately strong

door without a need of rear-framing; but such rear-framing continued to be widely used, and since the Ely door seems to be the sole example of both techniques being used for the same door it can be assumed—as seems apparent—that costs were approximately equal but specialist craftsmen rare. The cross-sectional form of the ledges forming door-frames also underwent some changes, the earliest examples being frequently of a half-round section which was wrapped with elongated roves against its splitting at the points where clenched; these evolved into square-sectioned ledges with chamfered corners, still similarly wrapped by their roves, and apparently produced the type noted at Durham and elsewhere in Essex. The Durham door retains semi-circular ledges but in a tapered form, which was driven into undercut housings worked across the planks; no additional ironwork was applied except to their front faces. This was a type of door lacking in strength—strength, that is, capable of resisting a forced entry—and one which exhibits an almost cabinet-making approach to the problem, and a similar delight in fine woodworking. The ultimate use of lamination for doors, such as the palace door from Norwich, is really a cheapening of the door-making process and one that seeks to reduce the degree of skill necessary to produce the article in question. This fact, when considered with the lavish application of carved ornament applied to the front, questions the merits of the whole. Ideally, as in the case of the early doors at Selby, the actual construction is synonymous with ornament, which latter was probably carried close to the limit of good taste in the cases where the framing was chamfered.

Door-hanging was of two types only. The early case at Peterborough apparently had the timber forming the harr reduced to pivots at both top and bottom, and these when iron-bound were provided with suitable sockets in which they could rotate. The later types all used hinges of iron, of the hook-and-ride category; this gave an opportunity for strengthening the woodwork by extending the strap of the ride across the face of the door, and great scope for the blacksmiths to produce naturalistic and plant-like decorations. The bars with which the doors were in early times secured, after closing, also show two phases. The earliest seem to have been fitted vertically; this must have needed a strong man, since the heavy piece of timber had to be lifted bodily from its sockets and carried out of the way—an example of this survives at Lincoln. Later examples had this bar pivoted, at a point near the centre of the doors, as at Ely, and the bar could then be swung into its "locked" position without a need for manhandling.

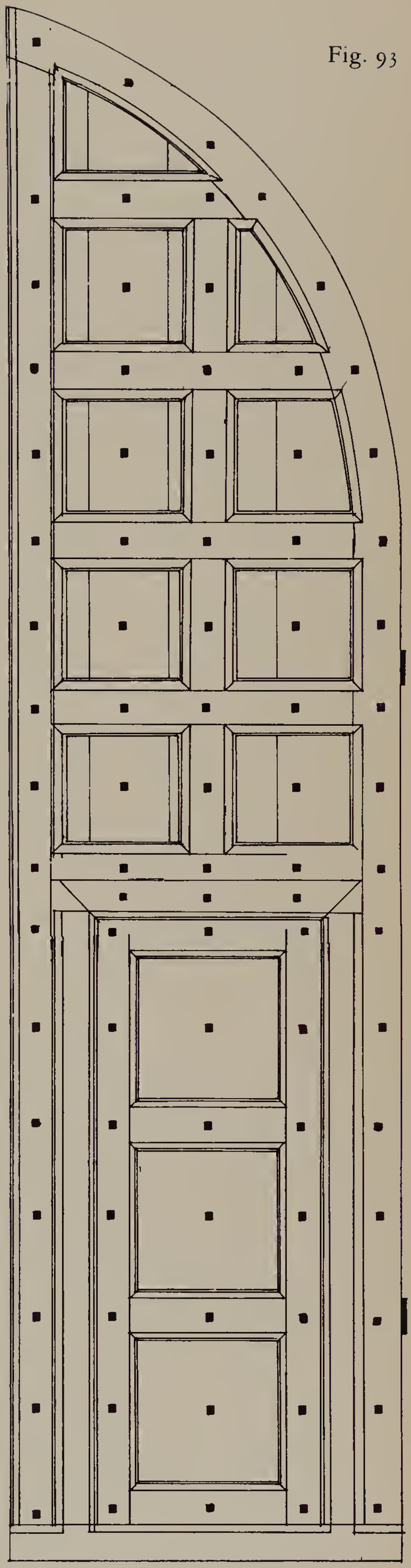


Fig. 93

7 CONCLUSION

The examples of ridged main-span roofing described provide adequate grounds for the formulation of a provisional course of development since these roofs number no less than forty, all of which were produced within the medieval period. This needs augmenting by a study of surviving roofs in monastic churches. Since they were also built in the cathedral tradition,[70] and in greater numbers, they may provide enough evidence to fill the gaps between cathedral examples of this kind. The "sample" provided is, admittedly, small to represent so many cathedral churches and cover so many centuries, but the chances of any of the individual roofs being atypical are slight while the extent to which they suggest an intelligible process of evolution is, in itself, the strongest evidence for that process. This is, inevitably, a circular argument, but an alternative and illogical series would be less acceptable.

Cathedral roofing involved two distinct categories: open timber roofs, and high roofs designed to protect vaults. The open roofs clearly preceded the latter kind, since the Saxon and Norman cathedrals were not vaulted, and the ceiled timber roof of the nave at Peterborough survives as a good example of the late twelfth-century type. A few re-used fragments of roof-timbers at Waltham Abbey enable a hypothetical reconstruction to be made of a roof representing an even older tradition having common tie-beams—to which a ceiling might also have been applied. Toward the close of the twelfth century the scissor-braced rafter-couple seems to have appeared; this constituted a definite advance in structural soundness, but with its seven-canted archivolt it did not tend to sustain the taste for decorative ceilings, and no surviving examples show evidence for attached ceilings, despite the fact that they might have looked more attractive than the preceding flat ones. Since more than one type-series is involved, from at least as early as *c.* 1170 when the nave of Peterborough was building, it will probably be most easily intelligible to trace the apparent developments of single features from beginning to end, thereby covering the same period more than once, each time by a different route.

In this way the tying of roofs is a suitable thing to begin with, and the examples provide a lot of information concerning the principle. It is obvious that adequate tying must have been a major concern to the

cathedral carpenters since their roofs were not only of the widest span possible, but were also built at the greatest practicable height above ground; this gave the roofs a huge mechanical advantage over the bearing-walls—often in the form of an eighty-foot-long lever, since the higher the wall the greater its leverage upon its foundation. It is not surprising in this context to find evidence at Waltham Abbey for a roof that was tied across the base of every rafter-couple, as was clearly the case before its "restoration" in 1807. A date for the western part of the Abbey church is from *c.*1110 until the middle of the twelfth century, when it would have been completed. The next in historical succession is the nave roof of Wells Cathedral, which is probably a derived form since it also has two collars, with the added feature of crown-pieces. This feature was introduced in order to dispense with common tie-beams, and achieved this by vertically coupling the two collars and tying the rafters to the centre of the lower one—a form of couple designed to contain its own outward thrust. It is regrettable that this roof was converted to parapets since this conversion removed all evidence of the original eaves, wall-plating and tie-beams; but it seems likely that tie-beams may have been provided for every third couple. The Wells nave is dated between *c.*1174 and *c.*1230, and had its "break" in building continuity between *c.*1209 and *c.*1213, which provides a latest possible date for the completion of its oldest portion. Of the same period are the three eastern arms of Lincoln, among which the northern transept seems to retain its original high roof fitted with tie-beams to every third rafter-couple, in addition to having an unusually steep pitch that yields more weight than outward thrust. Among the earliest examples included in this series no less than nine roofs were fitted with tie-beams to every third couple, and this may well have been the normal practice during the earlier part of the thirteenth century. Sometime before the middle decades of this century the next development was introduced, tie-beams fitted with branching ends of which examples survive at Salisbury in the northern choir transept, and did exist until recently in the presbytery and northern transept of Westminster—these two being dated by their respective completion dates to 1237 and 1259. The fourth, fifth and sixth decades, therefore, of the thirteenth century advocated branching tie-beams, and also applied this principle to raking-struts as the roof of Chichester Cathedral shows. The direct result of fitting such branching ends to timbers, whether of compressed or extended function, was to spread their action in either terms; such tie-beams performed the functions of three of their kind, and the branching raking-struts achieved the support of a considerable length of purlin. In this way timber was used more effectually, since the

functional value of several components was performed by a single component suitably modified—a highly significant advance in design that achieved greater efficiency by more economical use of material.

From some time close to the end of the twelfth century another type of roof had also been developing, which aimed at requiring no tie-beams at base-level, the eaves; this was the scissor-braced rafter-couple in its notch lap-jointed form such as survives at Peterborough. In such couples the tying function is performed by the lower collar, which has unwithdrawable end-joints while the lower ends of the scissors act as tying soulaces. One result of this concurrent development of different designs was their combination, which produced some highly stable roof-designs—such as that over the Lincoln north transept, steeply pitched to minimise its spreading tendency, of self-tying rafter-couples, and having a tie-beam to every third couple. Equal thoroughness was formerly displayed in the roof over Westminster's north transept, where scissored and self-tying couples were provided with branching tie-beams; and the Salisbury roof which is also of the middle decades of this century was also provided with highly efficient tying members in addition to self-tying couples. This period was, in the light of surviving examples, the best period of roof construction in this country, and a time when nothing was left to chance. They not only designed a roof that should not tend to spread; having done so, they took positive structural steps to ensure that it *could not* spread in the unlikely event of the first design failing. From such a point, of roof structures that were as enduring as their material, decline of both standards and craftsmanship were, it seems, inevitable—and did in fact follow.

Base-tied roof-designs adopted numbers of side-purlins that were braced, in-plane, to the principal rafters; while the lengths of the bays so tied steadily increased and not infrequently contained as many as nine couples of common rafters. The alternative designs that were aimed at no base-tying members and presumably derived from the scissor-braced type also continued to develop, and three of the latest medieval examples described are of this category; that at King's and the two at Bath Abbey. The primary motive for the evolution of such roof-types would have been the obvious difficulty of achieving a satisfactory solution to the problem, and it is anomalous in the cases cited to find such designs used as high roofs, which were not intended to be viewed from beneath. Tie-beams are not in any way undesirable in the loft above a vault. The designs at both King's and Bath are essentially weak and depend entirely upon the fit of their joints, which are not particularly good, and the strength of their pegging; immediately any failures in these points occur

they will exert disastrous thrust against their wall-plates. The introduction of curved timber was evidently effected quite early, and it seems to have appeared in the series of designs that were not base-tied, since in the church of the Grey Friars at Lincoln such a roof exists, and must have been partly completed before 1260. The roofs over the eastern arms of Wells, which are of the "high" variety, also show the use of bent timber in a manner that appears to be derived from the type at Lincoln Greyfriars, and also self-tying to a lesser degree. A third series of roofs may have been in existence during the latter part of the period covered—until the late thirteenth century—of which the nave roof at Oxford could be the oldest representative; but despite the fact that this series culminates, via Durham, in Wren's nave roof at St. Paul's it merits little discussion. The main event in its course of development was the change of king-post function; from being a compressed component it completely changed, becoming a pendant that was hung from the rafters' apexes.

The steps by which the earliest single-framed roofs, like that formerly over Waltham Abbey nave, evolved into double-framed roofs like that of the final design at Exeter have also left some material evidence among these survivals. Motivation for this development is not far to seek because any long series of singly framed roof-triangles is bound to "rack"—that is, to incline slowly from vertical, normally all remaining parallel since their cladding-battens provide distance-pieces. This "racking" must have preoccupied the cathedral carpenters from the opening of the thirteenth century, and one of the earliest material expressions of this concern is the fitting of the central, or collar, purlin into the high roof above the nave of Lincoln—of which part survives in the bays immediately west of the crossing-tower, which may have been roofed as early as *c.*1225. This purlin has the nature of an afterthought, since it is not framed into the structure but is subsequently housed over the collars' upper faces. Efforts to combat such racking were not confined, however, to Lincoln, where collar-purlins were developed, but were of two other types so far as the surviving evidence shows. The most reliably dated answer to this problem is that used for the high roof of Salisbury's north choir transept which had similarly housed side-purlins, mounted on canting-posts with straight bracing which has proved highly efficient. Somewhat later, so far as published dates are available for the work, Master Alexander tried diagonal bracing that was housed in the outer faces of the rafters, in his roof to the north transept of Westminster. This apparently failed because the braces themselves did not long survive, for reasons unknown; possibly they rotted owing to alternating wet and dry conditions. The carpenters building the roof of the Blackfriars

Church at Gloucester applied similar bracing, but spiked their timbers to the undersides of the rafters there, apparently with more success since these have survived in position. It is considered that their roof, over the nave, would have been completed by *c.* 1260. At this time, approximately, the high roof over the Angel Choir at Lincoln was building and this embodied a logical sequel to the central purlin noted in the nave there, since no less than three such purlins were fitted—one over the high collar, and two over the middle one; but no form of bracing was applied.

The combination of both types of purlin, those in the pitches, and those in the centres of the frames, survives in the third phase of the nave roof at Exeter—which was designed *c.* 1325 and was probably all in position by 1342, when canvas was bought to block temporarily the great west window.[71] The high roof over the eastern end, which apparently dates from *c.* 1290–1310, possessed side-purlins; and the final phase of building which carried this roof westward mounted both side-purlins and a true collar-purlin. The collar-purlins were short and tenoned into successive crown-posts, as previously described and illustrated, and the side-purlins were trapped very securely by vertical struts—open notched lap-joints were used in this work. Exeter therefore preserves examples of two highly important developments, the double-framing of scissor-braced couples and the most complete type of double-framing noted—that with both side- and centre-purlins.

Following this example there is a lack of consecutive evidence, but side-purlins with an unusually high centre-purlin had *possibly* been used before this date, in the high roof of Chichester Cathedral which may date from *c.* 1230 or earlier—only a dendrochronological or Carbon 14 date will determine this question. This possible exception apart, the greatest number of cathedral roofs with side-purlins only, often with two or three to each slope, seem to have been built during the fourteenth and fifteenth centuries; and by the unknown date at which the nave at Salisbury was re-roofed these purlins had become common purlins. The middle decades of the eighteenth century seem probable for this development, which was evidently approved by Wren, and was used fairly consistently until the nineteenth-century examples—such as over the choir at York.

There is evidence in this series for an interest, which started at least as early as the high roofs at Lincoln which embody such evidence themselves, for a proportion of the carpenters seeking to produce roofs that stood astride the crowns of the vaults; and these attempts do not appear to be connected with the designs that aimed at no base-tying, since they were frequently so tied, at close intervals. While this, as a theoretical method for high-roofing vaults, would obviously have been both prac-

ticable and desirable, in the examples that have survived none of the vault-crowns attain such a height above the eaves as to justify the design. There is a published example of this type in France,[72] over a transept of the "Abbaye Cistercienne de Noirlac" which is dated definitively to 1150–60, but in this example the vault-crown rises high in the space the roof so provided. The method used at Lincoln was similar, in effect truncated secondary rafters that jointed into the lowest collars (see Fig. 7); and this same method was used at Beverley Minster for the oldest surviving parts of the nave-roof there. Later it was used again for the Angel Choir of Lincoln, and still later for the high roof of the south main transept of Lincoln it was further developed—in this last case having jointed secondary rafters with raking-struts that reached the height of the third and top-most collars. A possible date for this last example is *c.*1320. Alternatively, and at Worcester Cathedral, the same effect was achieved despite the fact that the vaults were not high enough to warrant it, by stilting the frames on high ashlar-pieces. The method used at both Lincoln and Beverley may derive from secondary rafters, since carbon-dated examples of *c.* 1200–30 exist outside cathedral building,[73] but the object of the exercise is obscure at present.

The varieties of wall-plating used among the examples begin, of course, with the piece of north-eastern wall-plate that is still embedded in its masonry at Waltham Abbey; this is of the cross-cogged type, is single and laid along the centre of the string-course, in which it is partly housed. The common tie-beams having crossed this timber appear to have extended further till they reached the outer wall-surface, when a further plate seems to have been mortised onto their ends; and into this the rafters were set—in diminished stop-housings (see Fig. 2). Henri Deneux was able to be precise as to the period of use this cross-cogging technique enjoyed in France,[74] and gives *c.*1149–*c.*1225, which is more or less when it would have been used at Waltham. It is, otherwise than in this fragment, very little known in English roofs. No directly consecutive example to that at Waltham exists, but the next in historical succession must be the system existing in the choir transepts of Lincoln, which use two plates each—in two different manners. That to the north has these wall-plates housed in trenches cut from the soles' soffits, while that in the southern transept has the same system as was later used for the southern great transept: an internal wall-plate having a hewn fillet along its upper face which fits into trenches cut from the soles, together with an apparently rebated outer plate. The type of wall-plate with a hewn fillet therefore seems to have continued in use between *c.*1200 and *c.*1320; and it is a system Deneux did not record in France. The Lincoln carpenter or

carpenters vacillated, however, since the oldest frames of the nave roof were given a single and central wall-plate, the jointing of which I have been unable to ascertain, while the roof of the Angel Choir seems to have had no wall-plates at all.

In the monastic field sometime before *c.*1260 the Blackfriars at Gloucester was provided with *three* wall-plates; a central one fitting into soffit-trenched soles and two others that merely provided bearing faces, along the inner and outer arrises of the masonry. Exeter is, in this respect, unique since as previously described the wall-plates there—if they can be so called—provided tenoned distance-pieces between the successive soles; but this may have wider implications outside the cathedral tradition since it has been observed elsewhere.[75]

During the middle decades of the thirteenth century systems were used at both Salisbury and Westminster with two wall-plates, of which one was mounted well inside the wall surface and directly supported the ashlar-pieces. Thereafter two wall-plates seem to be the general cathedral practice, and these two were later tied together by short keys having lap-dovetailed ends—as noted at Durham and Winchester.

Concerning the succession of carpenters' joints that was largely brought about by their progressive cheapening, in terms of both labour and economy of timber, much confirming evidence is given by the roofs in this field. The general trend has been published previously,[76] and only the joints in this series of roofs that expand it will here be described. In several respects this cathedral information gives some degree of precision to the times of certain developments in jointing, of which the most significant concerns the notched-lap category. These joints passed through three stages of development,[77] and were evidently imported into England by the Normans, in the absence of examples that suggest anything contrary; and the earliest specimens had an "archaic" shape such as is illustrated (Fig. 2) with regard to the roof at Waltham Abbey, and in this form failures occurred owing to the splitting of the relatively acute "notches". In these cases, of which the chapter-house vestibule-roof at Lincoln is another, the notches are so directly designed to prevent withdrawal that they were structurally weak as a result, and doubtless as a result of failures their shape was refined, and the notches were made more obtuse and subsequently stronger. Refined examples exist at Wells in the nave roof before the break, and this work is approximately dated by that means to *c.*1209. The next step in refining these joints was also taken at Wells, it seems, because when building was resumed there they were given their "secret" form, in which the notches are covered by a thin flange of timber—in order to make them look inefficient, and withdraw-

able. This odd fashion evidently spread far and wide, since examples are recorded in Essex, Surrey and Westminster to date, but it was apparently short-lived and the carpenters at Lincoln Cathedral seem, wisely, to have ignored it. In "secret" lap-joints the thickness of the covering flange must not be deducted from the overlapping portion or the result would be weaker, but precise measurements of examples have not yet been taken and it is possible that they were made of equal strength to "open" joints. The entire period of use for "secret" joints of this category, at the cathedral level, is between *c.* 1209 at Wells and 1259 at Westminster; no later examples have survived for examination and hypothetical allowances for continuance are a matter for pure speculation. As already indicated the master-carpenter at Lincoln took no notice of what the King's Carpenter was doing at Westminster; and therefore the fashion for secrecy cannot be said to have superseded open joints, and there must have been as a result two concurrent forms for about four decades, of which the spurious one dropped from use. Perhaps as late as *c.* 1330, when the south choir transept at Wells was dedicated (no date is known for its building), the open notched lap was again in use there, confirming the ephemeral nature of the fashion for secrecy at the very place where it seems to have been engendered. After this late date it also seems that these joints were no longer used, unless examples can be proved to date later in parochial or secular works of carpentry.

The second jointing technique that is highlighted by this study is the introduction of tenons with diminished haunches, these being devices to increase the strength of tenons which were entirely successful and are in use today. The earliest examples of this technique yet known are used to fit the side-purlins in the roof of King's College Chapel, Cambridge; and for the information concerning this I am much indebted to Mr. J. Saltmarsh of that college.[78] There were no less than three successive stages of building at King's; the first interruption was caused by the deposition of King Henry VI, and pinpoints no innovations in carpentry; but later, when work was halted owing to the uncertainties following upon the death of Henry VII, five bays at the eastern end had been timber-roofed—this work having been completed by 1483. The design was by Martin Prentice and the purlins, as shown in Fig. 33A, were fitted by means of unrefined tenons and masons'-mitres. The final roofing operation was in March or April 1510, by Richard Russell, and was completed by September 1511; and during this major part of the work tenons with diminished haunches were used for the purlins. The exact difference in the two jointing methods is shown in Fig. 33. Both parts of this roof look the same; only the improved joints indicate the position of the

break in continuity and were not, it seems, observed in previous publications on King's. These are the earliest diminished haunches known at the present time and must, though others are discovered, be very close to the actual date of invention.

The joints used to form a continuous length of timber from two separate lengths—scarfs—are also well illustrated by works in this series. Types already published will need little mention;[79] but some examples in cathedral roofs are new and significant. That various types of splayed scarfs were predominantly used during the whole of the thirteenth and the earlier decades of the fourteenth centuries is confirmed by these cathedral roofs; but the type used a great deal at Salisbury is the exception to this. The joint in question is shown in Fig. 17, and is definable as an edge-halved scarf, tabled, with square and vertical abutments. Some examples of this, at Salisbury, have "keys" driven between their tablings; and yet others have their tablings worked along a splayed halving-line. Two architects were involved in the earliest operations there, and one of these was probably the advocate of the scarf—possibly Elias of Dereham, who did the lady chapel.[80] One other roof has examples of the same scarf and is probably datable to the same half-century as Salisbury on that account: this is the nave roof of Winchester, described in the Appendix. A second, unique (to date) scarf exists in several positions in the timber scaffold of Salisbury spire which was added to that cathedral by Richard Farleigh between 1334 and *c.*1380. This is shown in Fig. 142 and defined as a through-splayed and tabled scarf with square-bridled upper butts, and is presumably attributable either to Master Farleigh or to his master-carpenter. Since this joint occurs low in the spire a date close to 1334 is logical for it. A third type of scarf exists on the intruded side-purlins of the nave roof at Winchester; this is shown in Fig. 153 and could be termed splay-edge-halved with square-butts, interlocking. This joint is usually impaled by a tenon where it has been seen.

One roof among all the survivals is of regional character. This is the high roof of the Latin Chapel at Oxford, and would not be surprising in a context other than a cathedral. It is neither larger nor better than the roofs of many barns in Oxfordshire, and its plate-yoked rafter-apexes associate it with cruck-building. Its jointing, particularly the scarfing (through-splayed), well supports an ascription to the mid-fourteenth century, when the chapel it surmounts was built. I can offer no explanation for this occurrence.

The diagrams forming Figs 94–101 show both the type series discernible among the total described and the examples that do not asso-

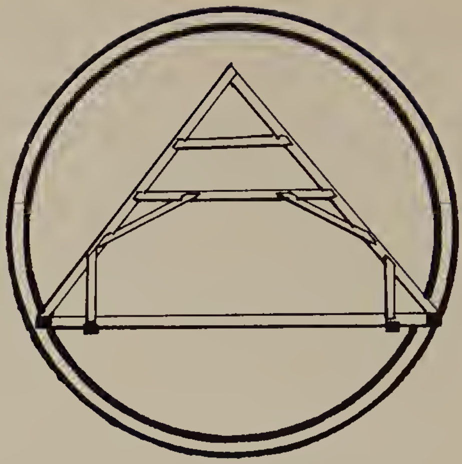
ciate without the inclusion of the wider variety of types existing in the field of monastic buildings—admittedly an integral part of cathedral building, but outside the scope of the present study. The evidence of Figs 94–98 indicates that double collars with soulaces and common tie-beams were being used in the second half of the twelfth century, and that double collars with scissor-braces and few or no tie-beams were introduced a little before *c.*1200, being used over the northern choir transept at Lincoln. Thereafter, and until *c.*1280, it seems, Lincoln pursued its own course, advocating secondary rafters that were gradually extended upward, and *apparently* developing collar-purlins. A little before *c.*1280 and also at Lincoln, the Greyfriars, compass-timbers were in use (and in all probability before, and elsewhere) and while these four types fairly clearly continue through the period (medieval) their main elements were evidently combined—as these examples show. All were introduced as single-framed, and all became double-framed, by one or other expedient. One well-known monastic church roof combines, for example, the notch-lapped compass-timbers of the Lincoln Greyfriars roof with the two "queen-like"-posts used at Salisbury, Winchester and Lincoln's Angel Choir, and scissor-braces and several side-purlins. This example is over the north transept of Tewkesbury Abbey, and must date from the same highly experimental decades of roofing. I have no doubt that many other permutations of such roof-designs formerly existed, and possibly some others await recording. Westminster's north transept had, according to my notes and photographs taken before its replacement some years ago, absolutely clear joint-evidence for some form of central posts that were notch-lapped past its collars and scissors that once existed, as was also true of the presbytery there; a great deal more evidence of this kind is needed to account for the appearance, at Chichester, of the extremely tall crown-post used there. Monastic buildings, it is to be hoped, will provide answers since it is now evident that our cathedrals alone cannot.

The low-pitched roofs with king-posts and raking-struts, all of which were double-framed, are a distinct and linear series, but a definitive date for what seems to be the earliest is desirable; and some indication as to an origin for the type. One important roof, the open roof of the nave at Ely Cathedral, has been omitted because its jointing cannot be seen sufficiently clearly to place it in any of the several types of scissor-braces; but the thirteenth century would seem probable in that case.

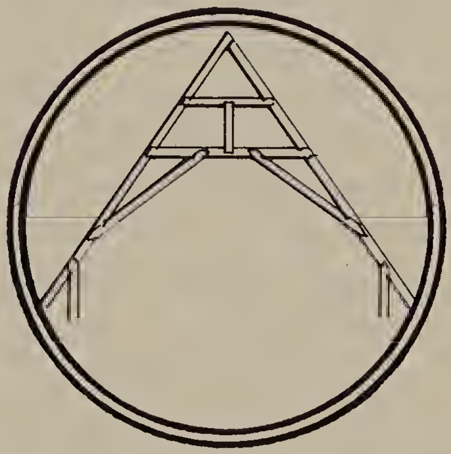
Fig. 94

Examples with seven cants

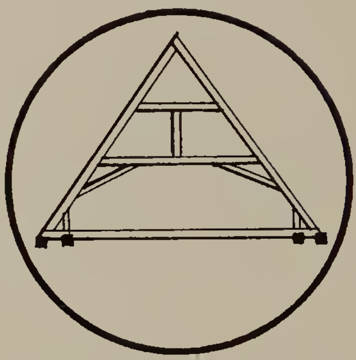
Lincoln. High-roof of Chapter House vestibule, Ch. Ho. building-dates – *c.* 1220–35. Open notched-laps.



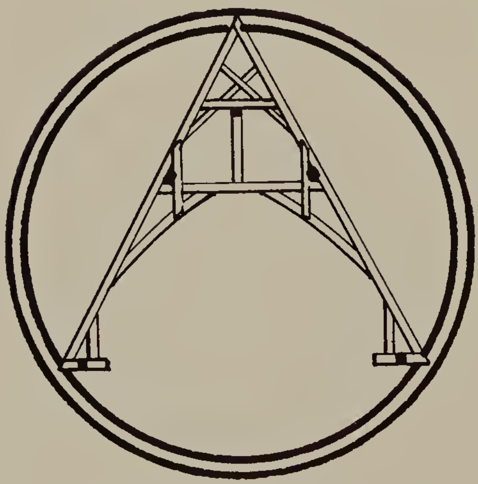
Waltham Abbey. Hypothetical re-construction of nave-roof from timbers re-used: ?*c.* 1110–50. Open notch-lapped.



Wells. Nave high-roof from central tower as far as "break" of *c.* 1209. Open notch-lapped.



Winchester. Nave high-roof, later converted to queen-post and side-purlins. All chase-tenoned.



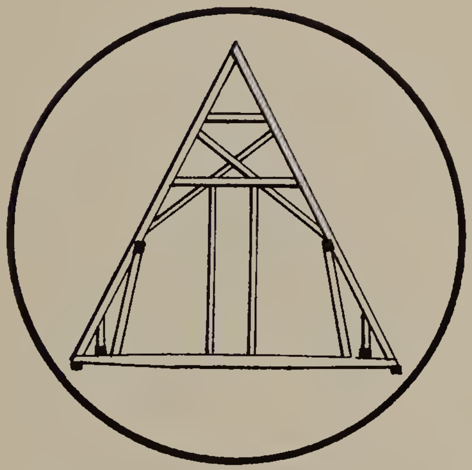
Exeter. High roof of nave, third phase of roofing, *c.* 1325–42.

Winchester. High-roof of South transept, single-framed.

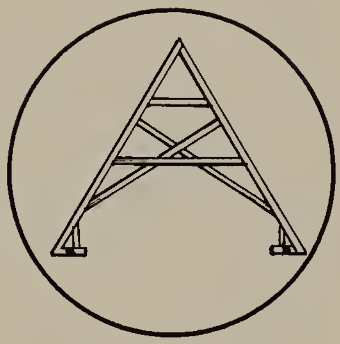
Fig. 95
Scissor-braced examples

Peterborough. Seven couples over North West portico, found by R. Reuter to fit nave if hypothetically completed, and ?*c.* 1175.

Lincoln. North choir transept high-roof, choir and transept dated: 1192–1200. Open notch-lapped scissors.

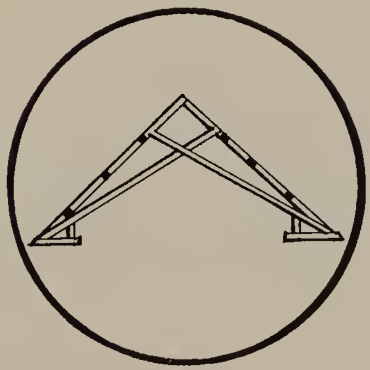


Salisbury. North choir transept, apparently the original high-roof, eastern arms 1225–37. Composite scissor-braces, chase-tenoned.



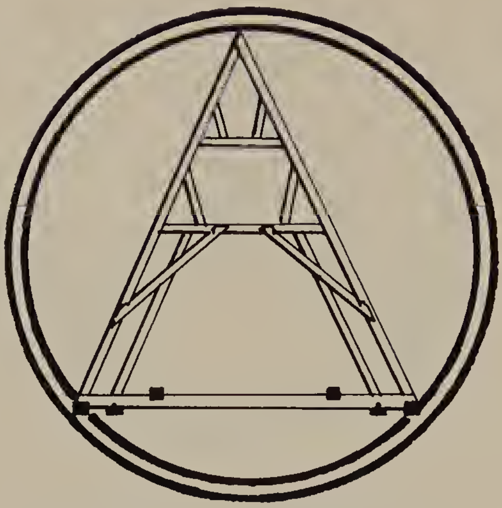
York. Chapter House vestibule roof, *c.* 1280. Chase-tenoned scissor-braces.

Exeter. High-roof of Presbytery, *c.* 1290–1310. Open notch-lapped scissor-braces.



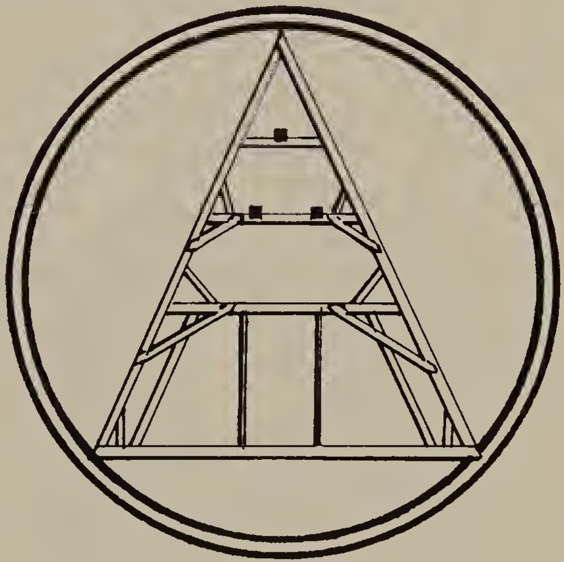
Hereford. High-roof over Lady Chapel, for which no probable date is available.

Fig. 96
Truncated secondary-rafters



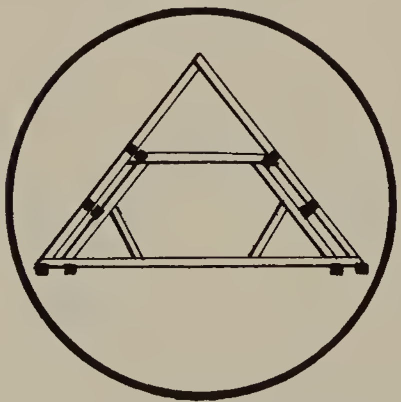
Lincoln. South choir transept high-roof, double-framed at base, open notched-laps. Transept building-date *c.* 1192–1200.

Lincoln. High-roof of nave at western end, double-framed; *c.* 1225.



Lincoln. Angel Choir high-roof, building-dates 1256–80. Double-framed, open notched-laps.

Lincoln. South main transept, building-date *c.* 1320.



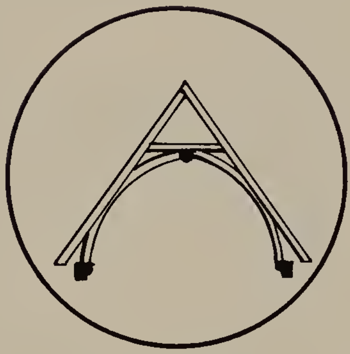
Durham. High-roof of Choir, no date known but ? Commonwealth restoration.

Fig. 97
Collar-arched roofs

Lincoln. Greyfriar's. Open roof of East part – by *c.* 1260. Open notch-lapped, single-framed.

Wells. South transept, no date known.

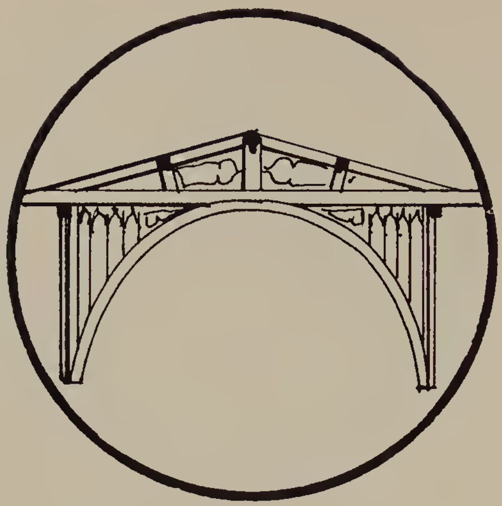
Carlisle. Choir, building-date for upper walls – 1363–95.



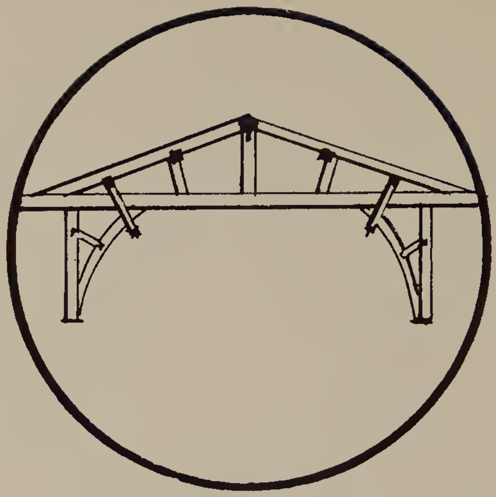
Chichester. Older part of cloister, built *c.* 1400–1500.

King's College Chapel. Roofed, second phase, 1512.

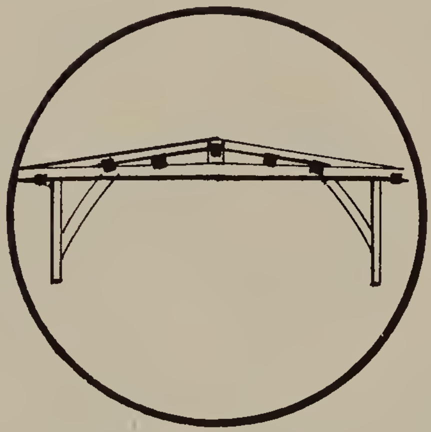
Fig. 98
King-post, examples



Oxford. Open roof of nave, building-dates: 1158–80. No date known for this roof.

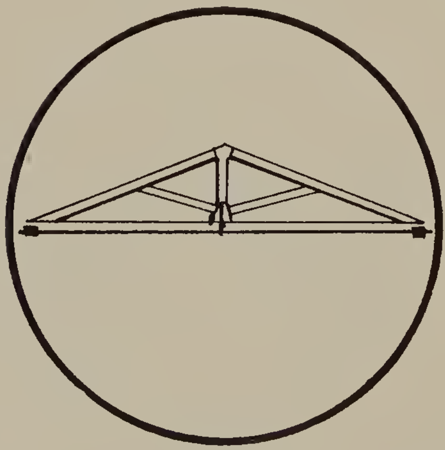


Durham. Open roof of Dormitory, 1398–1404.



Bristol. High-roof of Choir *c*. 1311–40, *if* original.

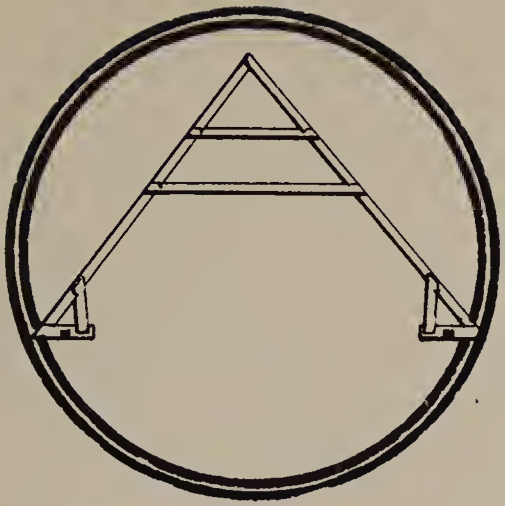
Hereford. Open roof of cloister, ?*c*. 1412.



London. St. Paul's, *c*. 1710.

Exeter. Chapter House roof *c*. 1413–39.

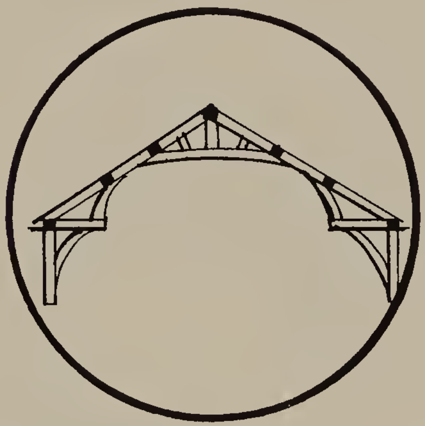
Fig. 99
Roofs not easily related to others



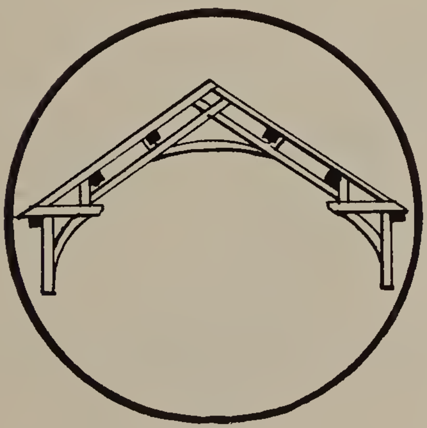
Peterborough. Precinct carpentry, open roof of Infirmary Hall, *c.* 1180. Notch-lapped – possibly earlier in date.

Chichester. Main high-roof, over nave and Choir, double-framed, high crown-post. No relevant date known after fire of 1188. Comparable roof in France on Maubuisson Barn, dated to *c.* 1230. See note.

Hereford. Lady Chapel high-roof, no relevant building-date available.



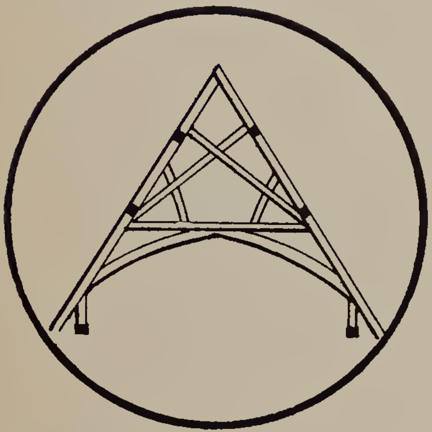
Bath Abbey. High-roof over nave, of 16th century. (Diminished haunches.)



Bath Abbey. High-roof over choir, between 1501–39.

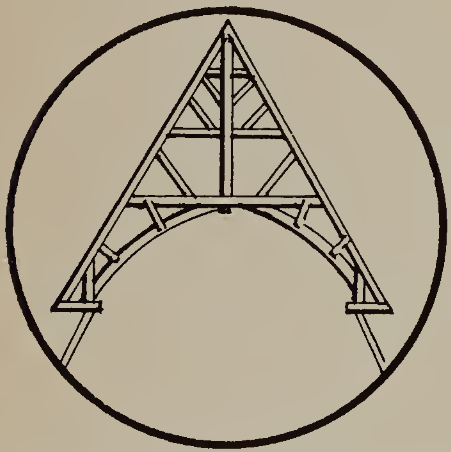
Fig. 100

Roofs not easily related to others



Canterbury. High-roof over North main transept, transept dated: 1448–55.

Winchester. High-roof of Presbytery, itself dated: *c*. 1315–60. Presbytery clerestory dated: *c*. 1520–32 – roof probably of later date quoted.



Worcester. High-roof of greater part of nave, made of re-used, notch-lapped roof-timbers. No known building-date that is relevant. ? late 14th century.

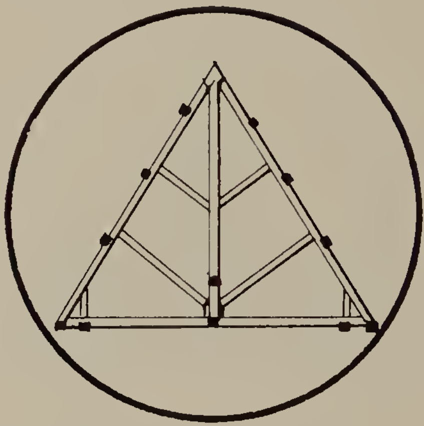
Worcester. Western bays of nave high-roof – no relevant dates available.

Winchester. High-roof over North transept—apparently by the same master as preceding example.

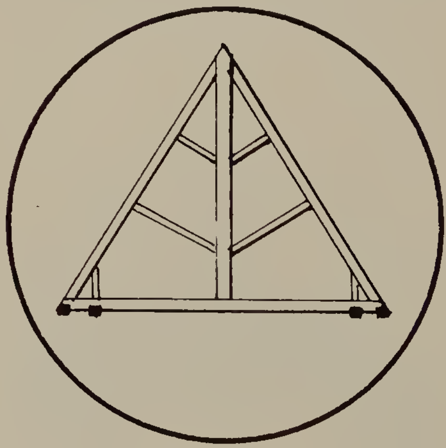
Fig. 101

King-post, seventeenth century

Lichfield. South transept, high-roof. General restoration, 1661–69.



Worcester. Three eastern arms, high-roofs: apparently 17th century.



Winchester. High-roof of nave at West end, believed 1669.

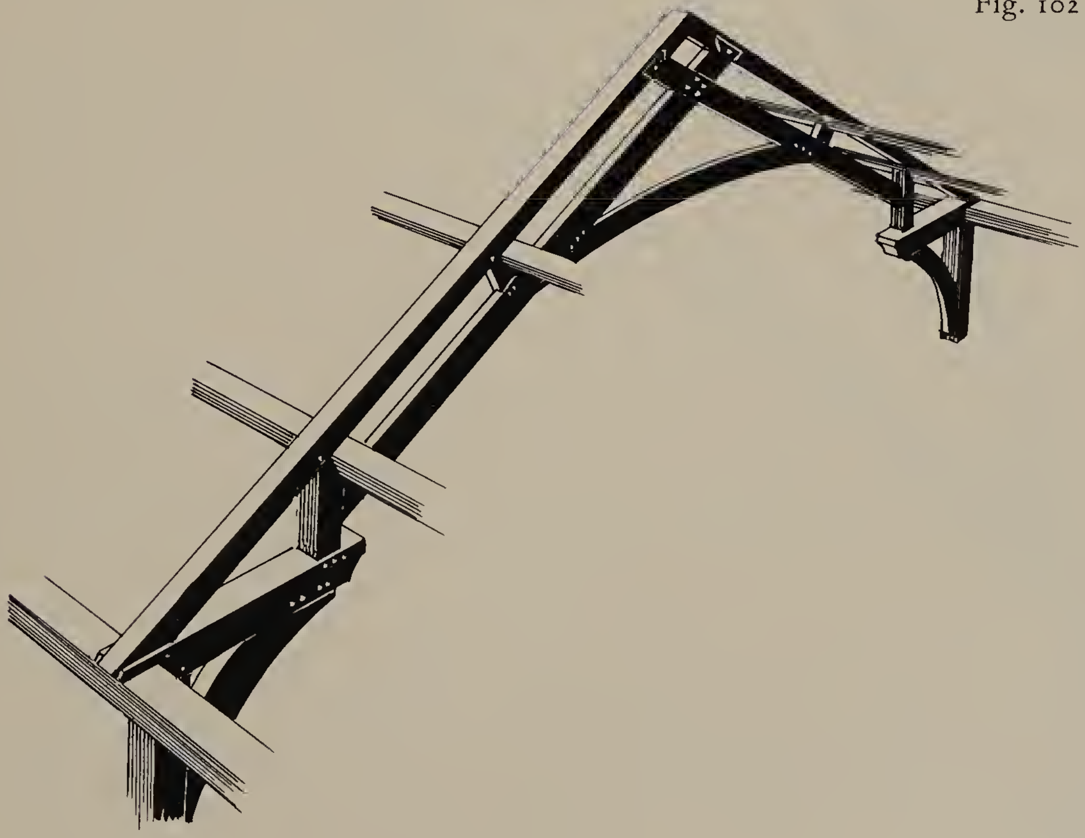
APPENDIX

Bath Abbey

Relevant building-date: 1501–39—present cathedral

The high roof of the nave is apparently the original one built for the present church, presumably by carpenters appointed by the brothers Vertue, who were themselves master-masons. A bay of this roof is shown in Fig. 34 and described under ridged roofing. The vault beneath was added by Sir Gilbert Scott between 1864 and 1873, the roof having been designed as an open one. It has been much restored since the vaulting, and spoiled with creosote. The common rafters have tenons with diminished haunches fitting them to the ridge-piece. The high roof of the choir is complex and apparently has timbers missing, among which were wind-braces that rose in a curve from the upper side-purlins to brace the principal rafters near their apexes. The transverse frames are as shown in Fig. 102, in which the lower of two side-purlins is mounted on a hammer-post, itself on a hammer-beam; and from the inner edges of these posts scissor-braces extend to the opposite principal rafters, into which they

Fig. 102



fit with barefaced lap-dovetails of crude shape. Curved collars complete the assemblies, with struts to mount the upper purlins in each slope. This is thought to have been designed as a high roof and clears the existing vault-crowns by less than head-room.

The west doors are of known date, 1617, when given by Sir H. Montague. Carved oak in very deep relief.

Bristol Cathedral

Relevant building-dates: 1140–8—Norman church
*c.*1311–40—choir

The high roof of the choir is possibly the one initially built to cover the vaulting. If this is the case, its design is advanced, but less so than is the unique vault. One bay of this is shown in Fig. 22. It is today in relatively poor condition and creosoted. A definitive date for this would be interesting; it incorporates no jointing techniques that would preclude an early date.

Canterbury Cathedral

Relevant building-dates: 1070–7—Lanfranc's church
1448–55—north transept
*c.*1515–20—Christ Church Gate

The only surviving medieval roof at Canterbury is the high roof of the north-western transept, which is illustrated in Fig. 30, and would seem to date from the building of that arm of the Cathedral. This is described under ridged roofs.

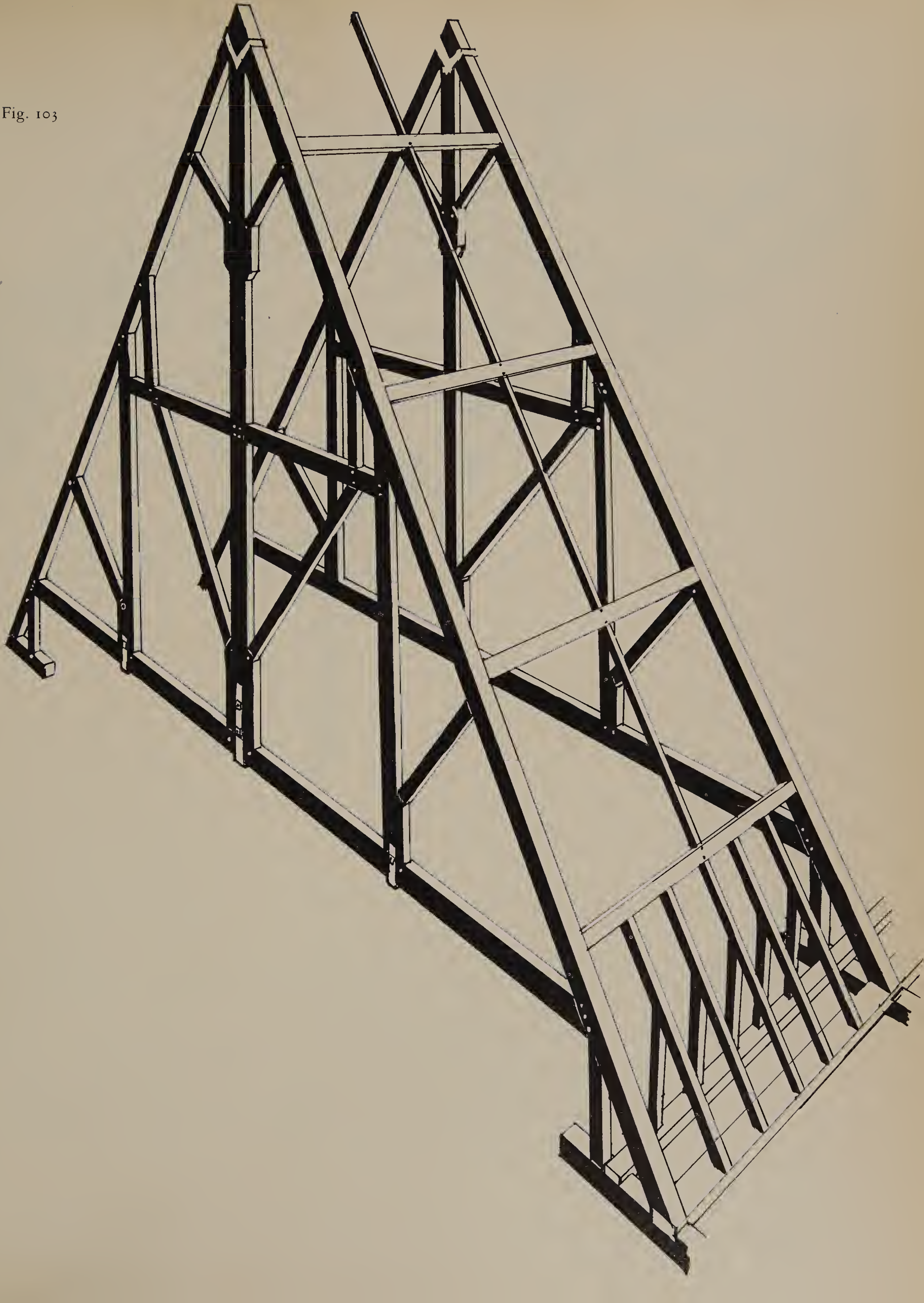
The south-western transept has a high roof of interest, which is of late eighteenth- or early nineteenth-century character, in five bays of seven feet in length with five common rafters per bay. The trusses and rafters are of mixed oak and pine without ironwork.

The nave high roof, westward from the central tower, has twenty-two similar trusses of a comparable but unknown date.

The south-eastern transept has an impressive roof, of the high type, surmounting the vaults; this is illustrated in Fig. 103 and is dated by carving on a tie-beam to "1771"—framed in oak, creosoted. Good trusses combining both king- and queen-posts are set stilted, their ties being above the ashlar-pieces. Notes read: "Two similar trusses in N.E. transept."

The low-pitched roofs to the nave aisles are framed throughout as shown in Fig. 104, with fifteen frames to both north and south; these are massive and have survived in good order for that reason. The curved braces have an arcature that might be of the late fourteenth century, but

Fig. 103



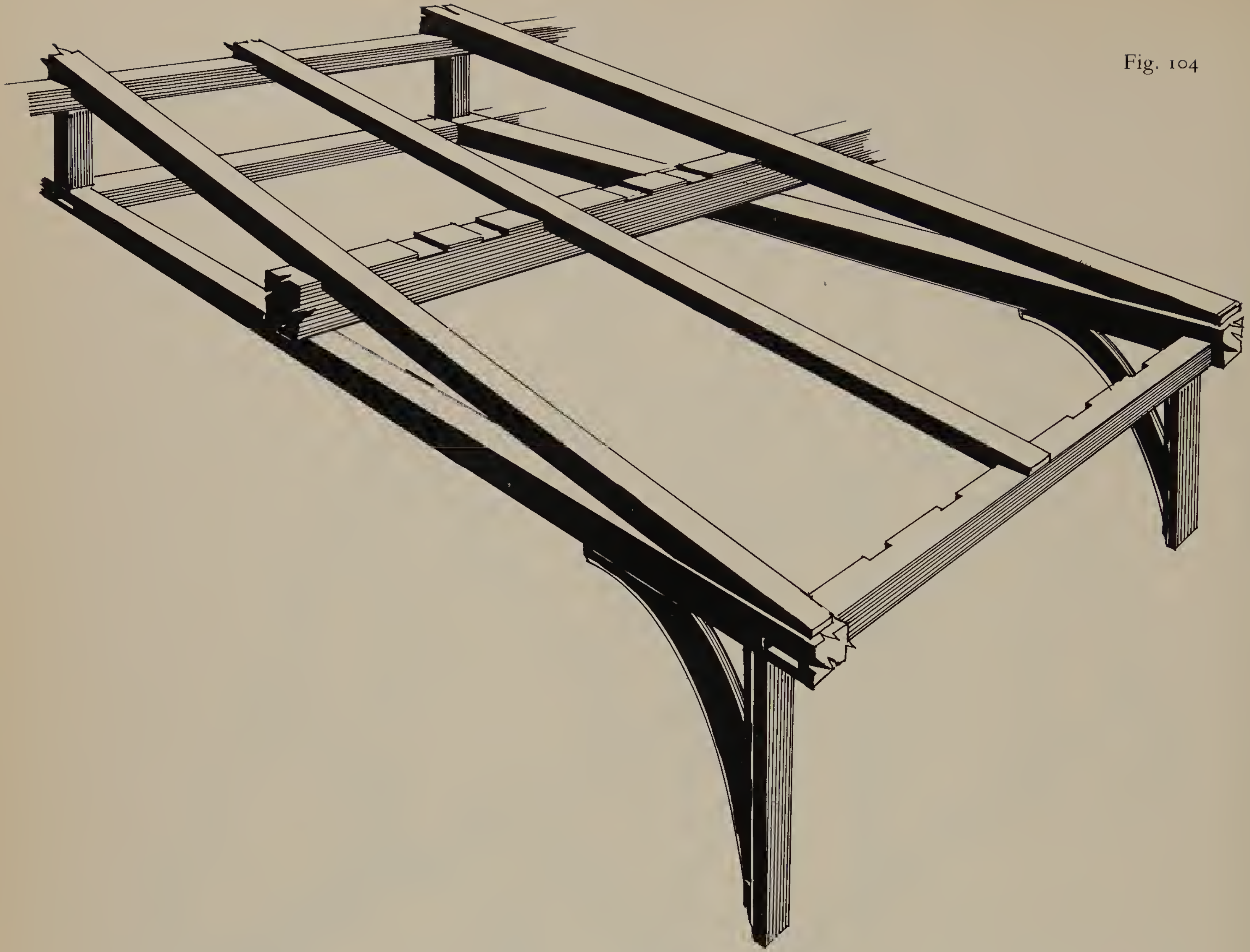


Fig. 104

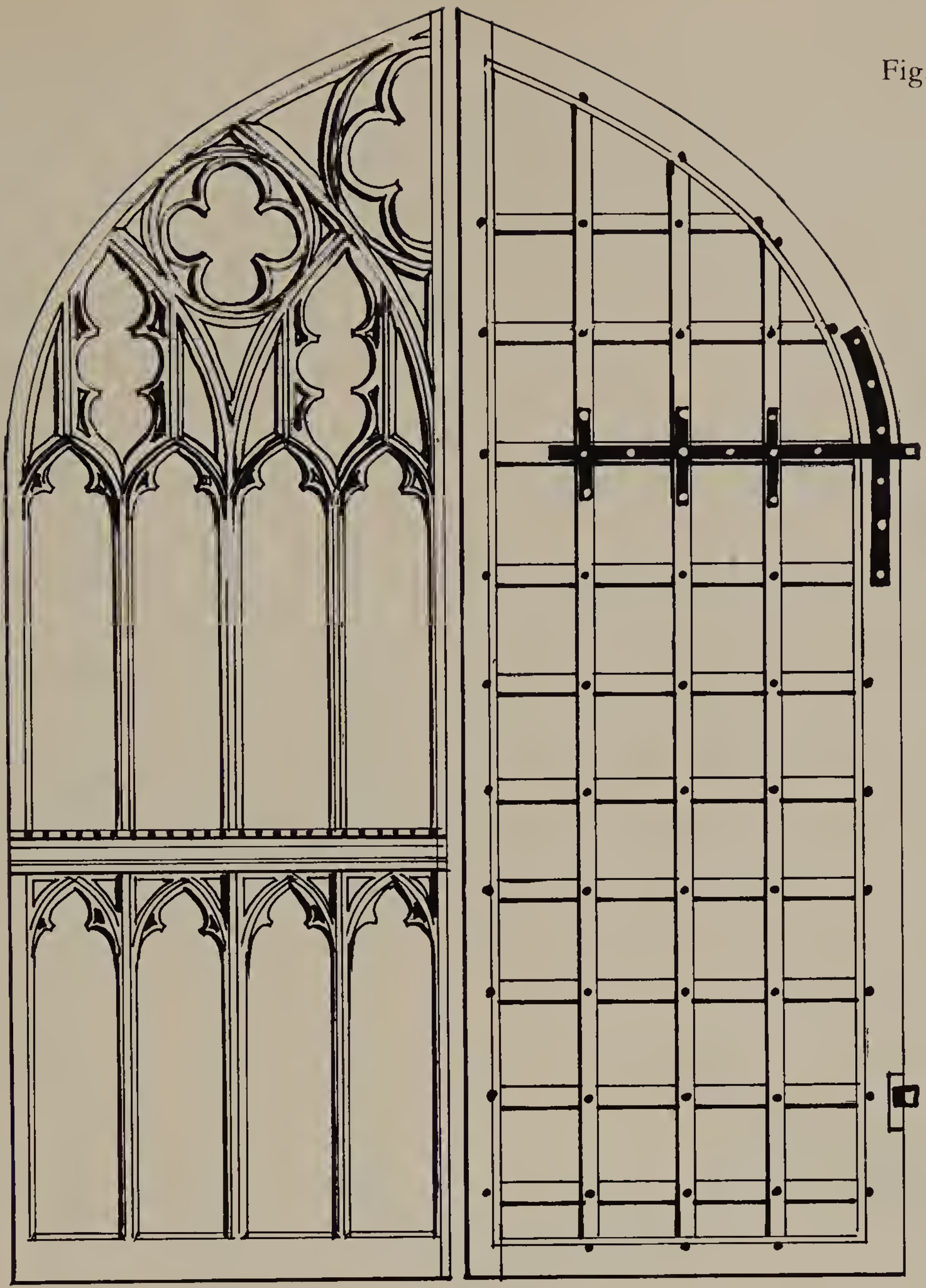
there are no other indications as to the date. The braces were originally fitted to both ends of the beams.

The west doors, constructed in two halves with vertical and central shuts, are traceried on the outer face, as illustrated in Fig. 105, which shows the same half-door from both inside and outside. It is possible, in view of their design and quality of workmanship, that these may date from the period of Prior Chillenden (1391–1411). The crossed ledges of the rear-frames are half-lapped under the stiles, or durns, which are chamfered and a quarter-inch proud.

The doors fitted to the Christ Church Gate, itself of *c.*1515–20, are probably of the same date, deeply carved and heavily framed.

A windlass of the walk-wheel type, has survived in the Bell Harry Tower of 1439–97, which is believed to be contemporary. This was not examined.

Fig. 105



The chapter house has a very fine roof of the fourteenth century, but this could not be examined since at a great height and not provided with access.

Carlisle Cathedral

Relevant building-dates: 1245–92—choir, aisles and arcading
1363–95—upper walls of choir

A curious roof to the south transept, too high to be examined and too dark to be seen in detail; this is arched to the collars, on which are high king-posts with curving raking-struts—three common rafters per bay. The important roof is that of the choir, already described on p. 39 and illustrated in Fig. 27.

Of equal importance is the lean-to roof of the northern triforium aisle, which could date from *c.* 1292 along with the aisles and arcading. Part of

this is illustrated in Fig. 106—one frame comprising tie-beam, wall-piece or helve, arch-brace; raking-strut, purlin and top-plate set into stone hooks. The purlin-scarves are as shown inset and are both pegged and spiked. The sole-pieces are trenched across their undersides to house a wall-plate now replaced by a course of brick. The later date for the upper choir-walls could be equally suitable for these frames and their joints.

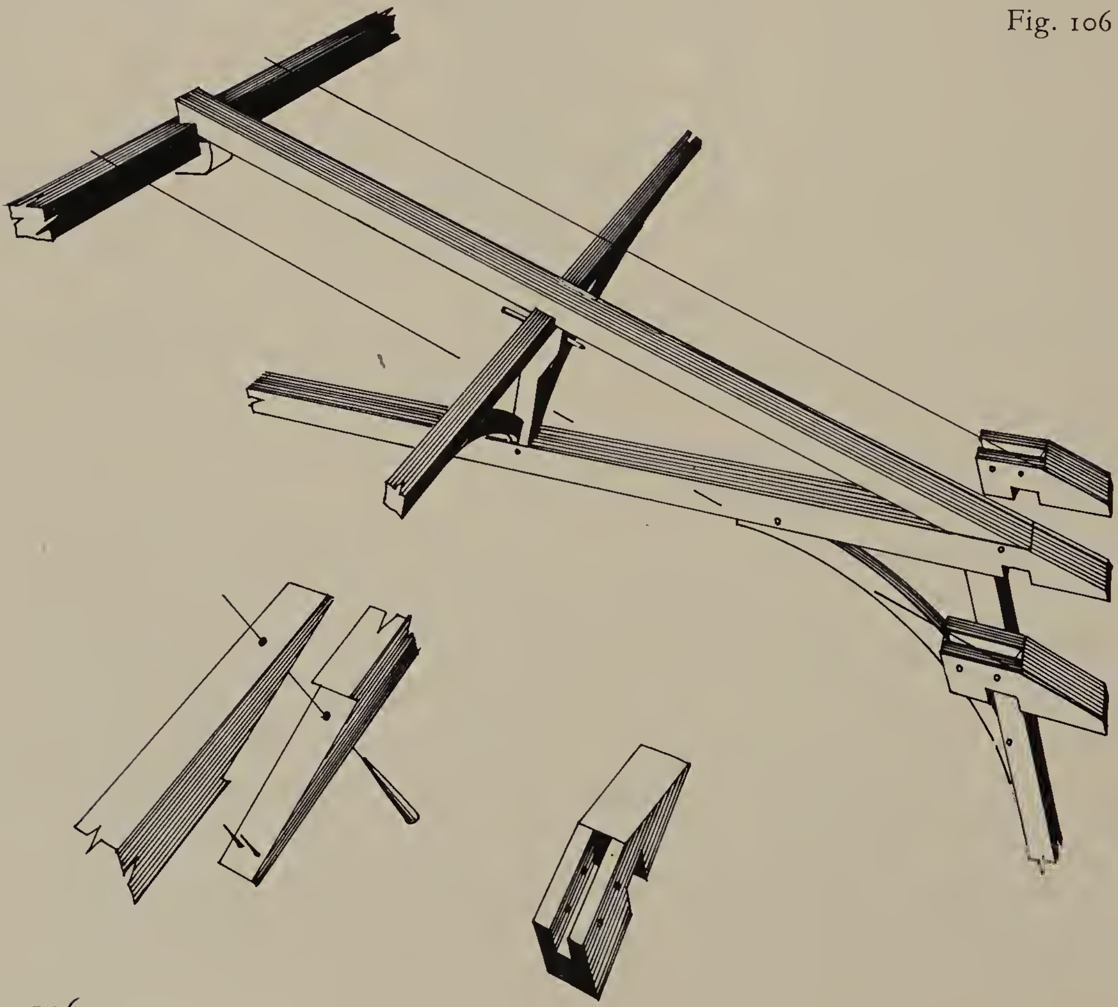
Chester Cathedral

No relevant building-dates known.

The lady-chapel roof (chapel of 1265–90) is inscribed "HE 1864", a date which precedes the restoration by Sir Gilbert Scott. This has trusses set on brackets with queen-posts and a collar-king-post—all with raking-struts. King-posts strapped and cottered, middle purlins set square and raking-strut purlins set in-pitch.

The choir is timber-"vaulted" beneath a complex king-post roof that also has strapped and cottered king-post feet; its tie-beams are cambered and have two arch-braces on each side. The nave roof is similar, being also timber-"vaulted" with vault-rib timbers curiously framed; these have straight outer surfaces. All inadequately examined, but apparently not medieval.

Fig. 106



Chichester Cathedral

Relevant building-dates: 1187–99—rebuilding after fire
c. 1400–1500—cloisters

The choir and nave high roofs are of the same design, and possibly same build, after the fire of 1187; these are described under ridged roofs and illustrated by Fig. 16. They are among the least spoiled and most important surviving roofs in the kingdom.

The north transept has a queen-post roof with straining-collars in which secondary rafters cross the raking-struts and support the queen-posts—the whole without ironwork and possibly early of its kind.

The lean-to roof of the northern triforium aisle is of great interest, being eaves-bladed with spur-ties, the whole framed on wall-pieces. This is illustrated in Fig. 107, which shows its integration with the Norman-style windows. Plate-hooks exist for its top-plate, and the spur-ties are fully lap-dovetailed at the wall-plates. This is unlikely to date from any of the known, and published, rebuilding operations and the early fifteenth century seems probable for the work, in view of the similar roof to Table Hall at Peterborough, of the fifteenth century.

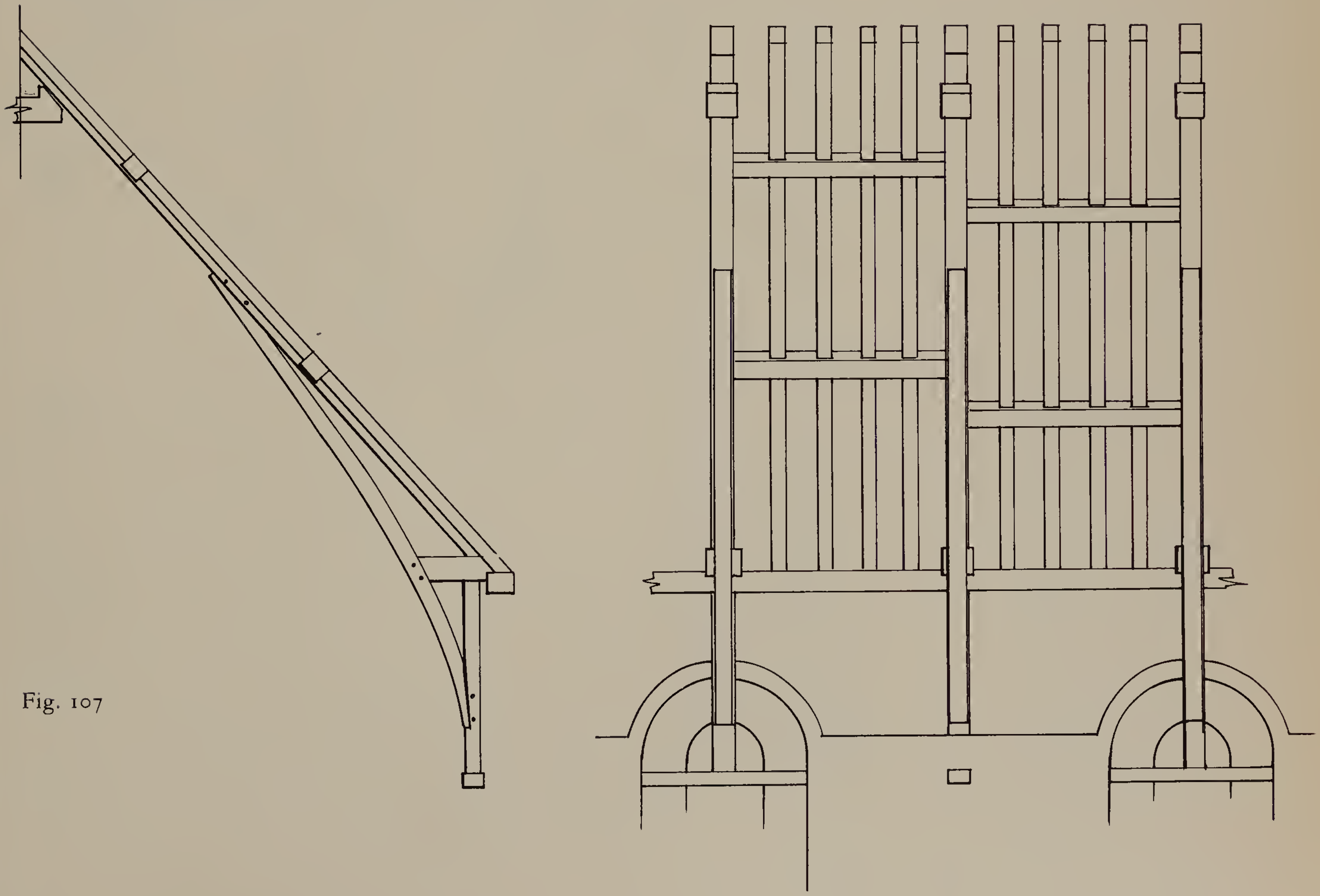


Fig. 107

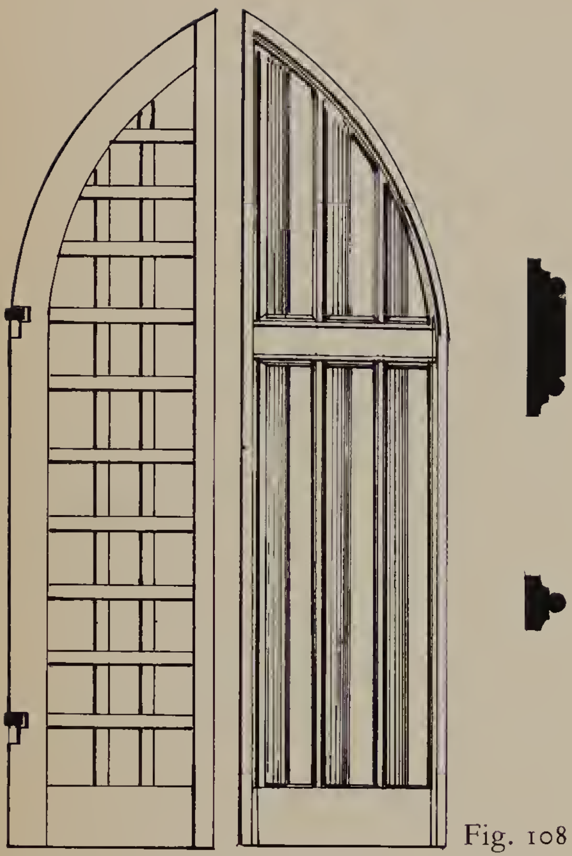


Fig. 108

The cloister roofs, on its three sides, are all of collar-arched type, built in four compassed pieces. The profiles of the wall-plates vary from one build to the next, the latest being the beaded casement; the wall-plates are double and keyed together—these are not illustrated in view of the difficulties in examination. This roof, at its south-western angle is remarkably contrived; the angle is bisected by an extra-heavy collar-arched frame into which all the others are fitted—in necessarily varying lengths.

The north-west doors, a pair of vertically halved ones, are well framed with continuous durns and squarely crossed ledges. These are illustrated in Fig. 108, which gives the sections of the rail and a face-muntin. The planks are humped on the decorative face. The doors giving access to the cloister are better, and framed with edge-durns and squarely crossed ledges; in this case the horizontal ledges are lapped into the durns from the rear face, clenched and with square roves on the rear. The hinges are heavy and much fullered at the edge-timbers; the mouldings incorporate many cyma-profiles. These are shown in Fig. 109. The west doors are, again, vertically halved and of squarely crossed ledge construction, with clenches and square roves at the base timber. One half, rear face, is shown in Fig. 110. Of uncertain date.

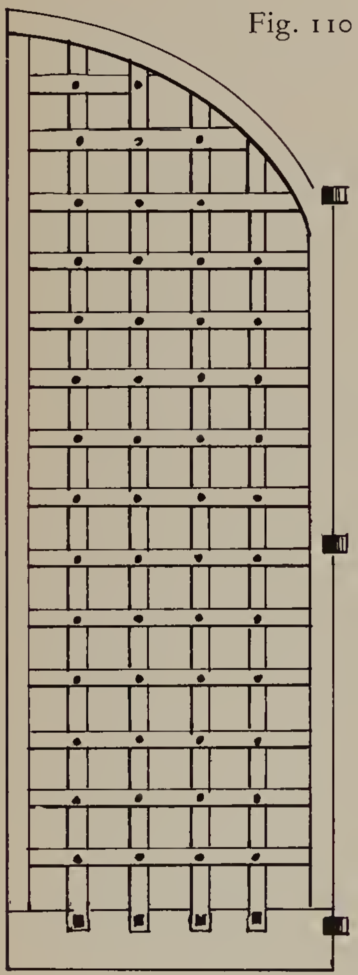


Fig. 110

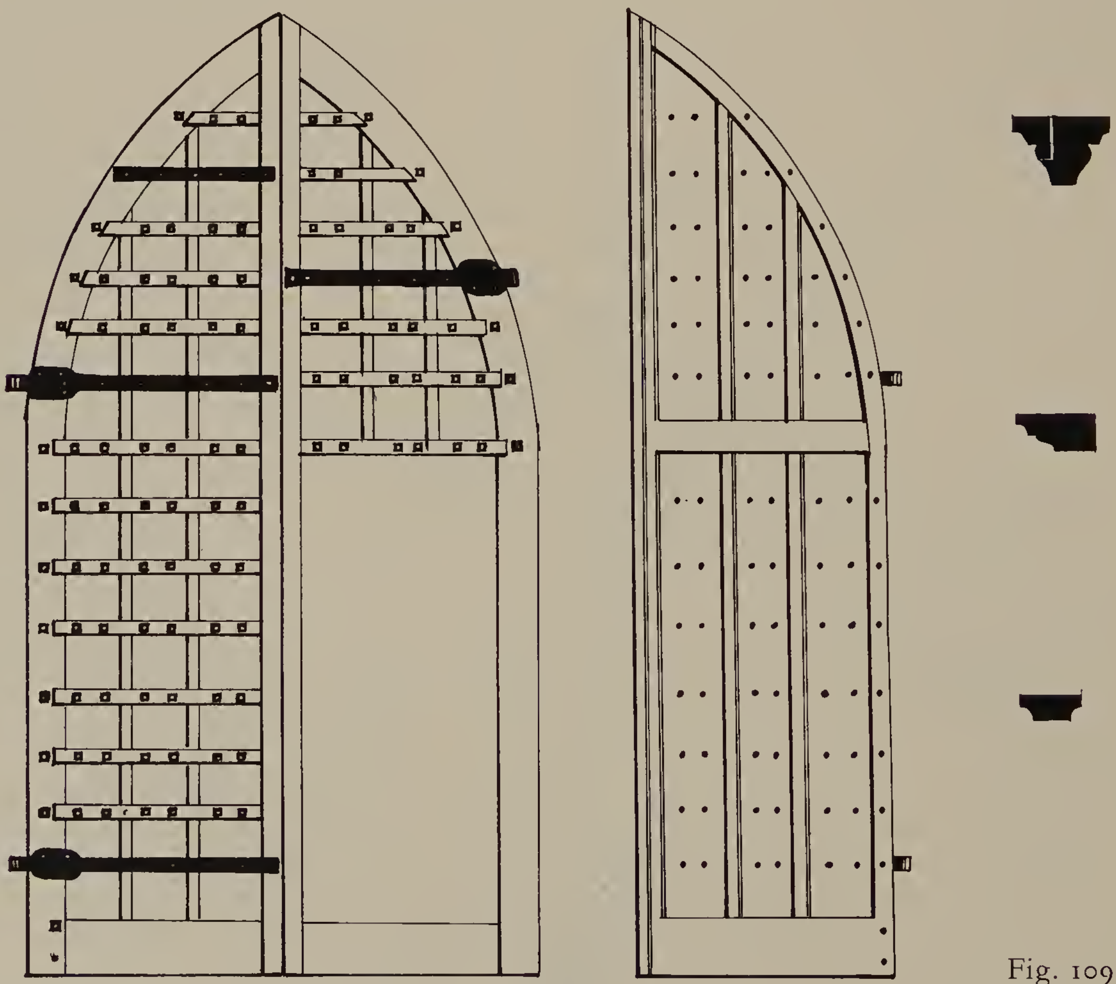
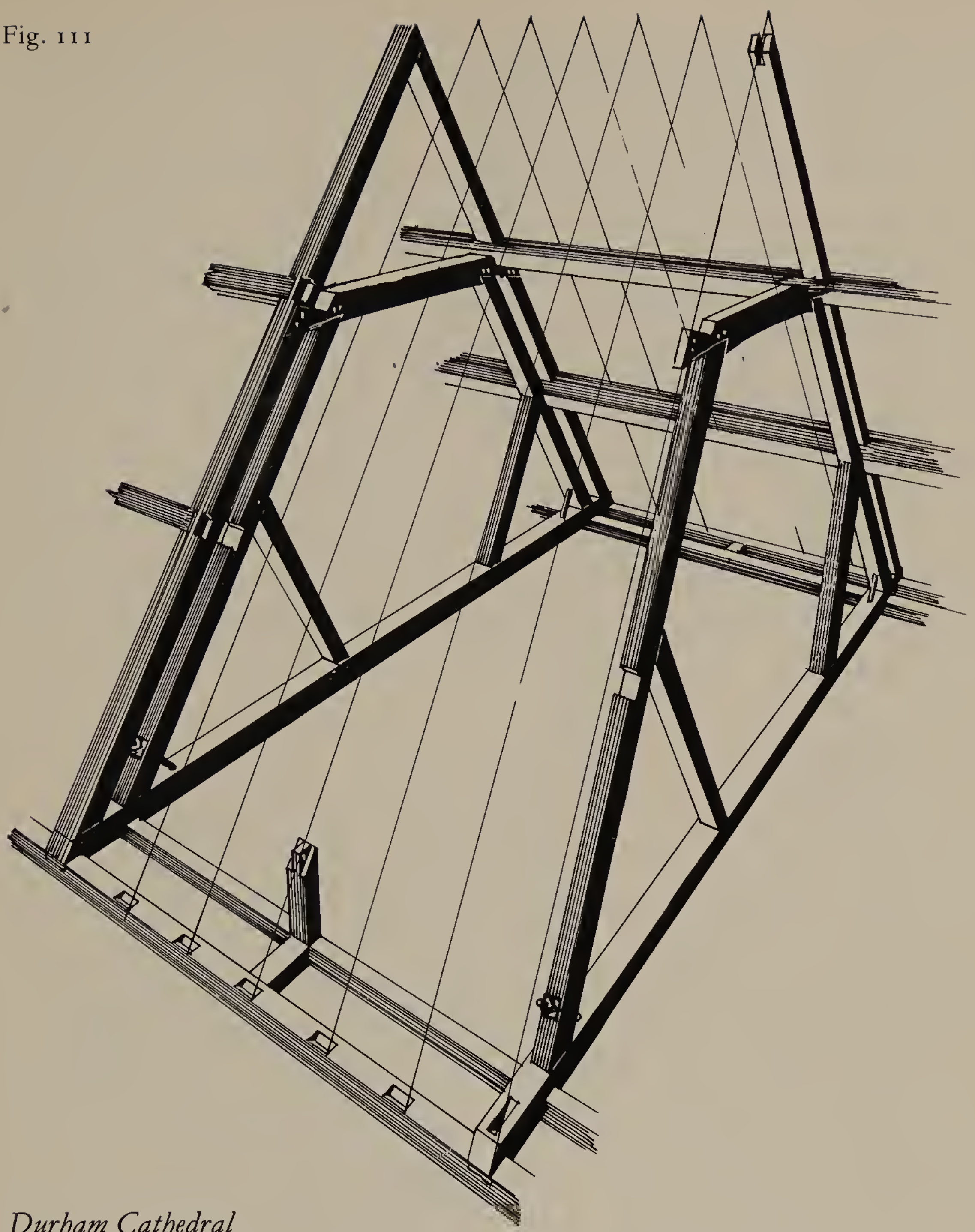


Fig. 109

Fig. 111



Durham Cathedral

Relevant building-date: *c.* 1220—west towers, upper stage

The most important roof surving at Durham is the high roof over the choir, of which one bay is illustrated in Fig. 111. This is of oak and has secondary rafters supporting the collars, which are lap-dovetailed and in turn support upper side-purlins. All side-purlins are doubled, as shown; and the secondary rafters are bolted—with threaded nuts—at their eaves. These bolts seem original. I am assured that the eastern arm of the Cathedral was restored, possibly by the architect James Clement who died in 1690,[81] and I assume that this roof would date from sometime before his death—perhaps from the third quarter of the seventeenth century. Were this so, the bolts would be remarkably early.

The timber roof of the Monks' Dormitory is described on p. 40 and illustrated in Fig. 28; it is dated between 1398 and 1404, the latter being its completion.

The high roof of the nave evidently belongs to a restoration; it is dated and signed in several places, the earliest being "Martin York 1849". This has queen-post trusses mounting king-posts on the collars, with raking-struts to both, truncated secondary rafters, four purlins each slope and well-bracketed eaves. The roof over the north transept is very similar.

A fragmentary windlass with compass-arms for two wheels is mounted in north-western tower—described and illustrated on pp. 68–9. There is also a capstan in the south-western tower, illustrated on p. 73.

The doors giving access to the cloisters are described on p. 90 and also illustrated. The northern doors into the Galilee are of good quality and have perpendicular mouldings on their members, with barefaced lap-dovetailed assembly of the cross-ledges. The roofs of the Galilee are of some interest.

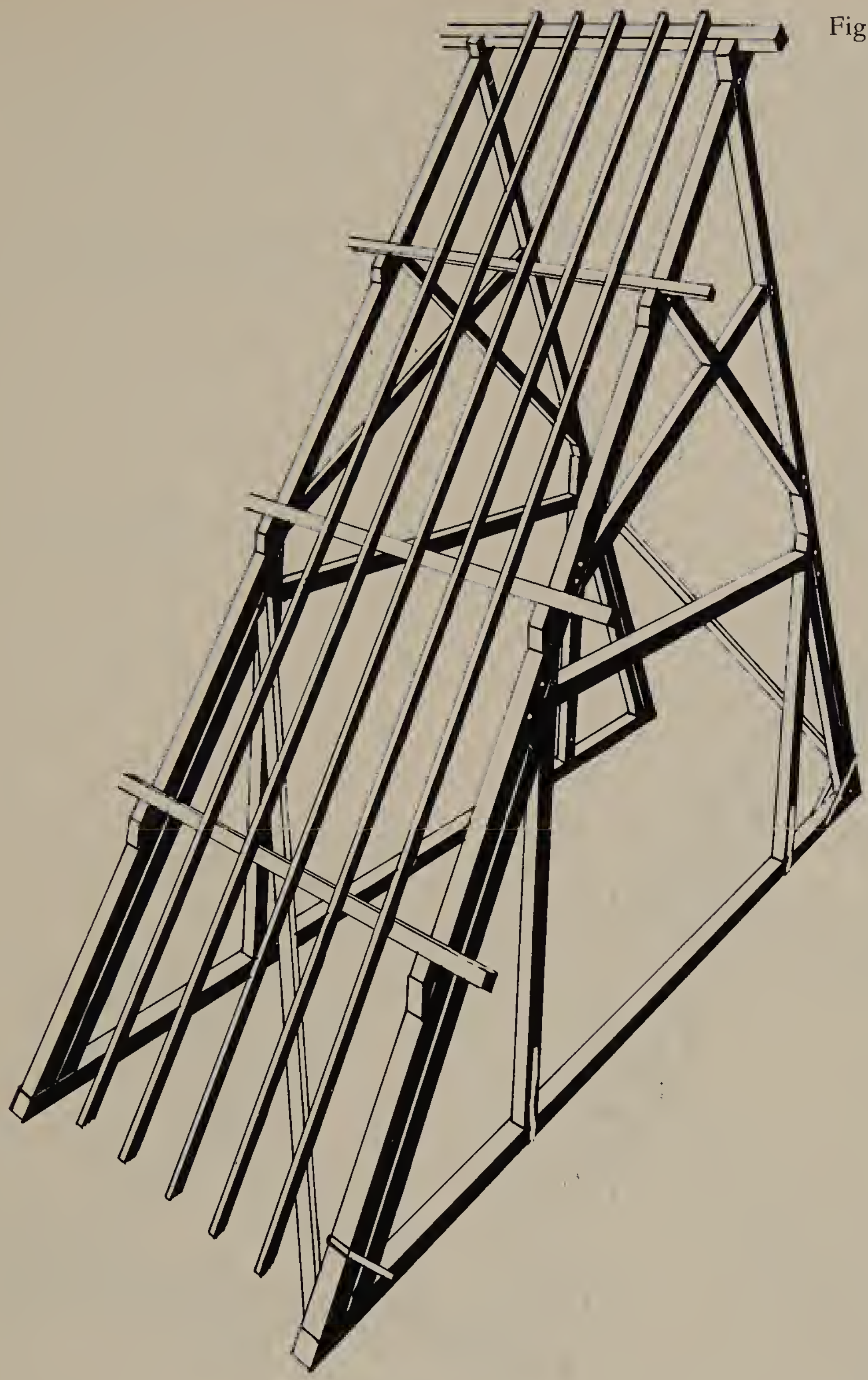
Ely Cathedral

Relevant building-dates: 1328–40—timber vault and lantern
1757–62—restoration by James Essex

The nave roof, which was an open timber roof until relatively recent times, cannot be examined because it is obscured by a planked ceiling, applied to its collars and scissor-braces. It does not appear to be an unusual type of scissor-bracing, and the joints that can be seen are those to the scissors' tops, their meeting with the rafters of which all are common; these vary and include barefaced lap-dovetails and full lap-dovetails. The ends of both high and low collars are tenoned. This is probably thirteenth-century, and moreover early thirteenth-century, but it cannot be dated until it is examined. The roofs to both main transepts are hammer-beamed and painted; these are perhaps traditionally ascribed to the fifteenth century. They cannot be examined, however, and no date ascription is here given. Both are undoubtedly medieval roofs and fine examples of the type.

The high roof over the choir is a good example of the mid-eighteenth century and results from the restoration by James Essex; several timbers are dated "Ia MAY 1768". The design is queen-post, the posts having cottered foot-straps and secondary rafters, while above the collars are scissor-braces. The principal rafters cross at the apexes, to cradle a ridge-piece—in cruck tradition—and there are three purlins each side. This is illustrated in Fig. 112. Essex in this case used forelock-bolts and an interesting halved and under-squinted scarf that is tabled and keyed; the

Fig. 112



whole is of pine, much of it adze-finished; unfortunately creosoted.

The lantern and its timber vault are described under that heading on p. 82, and the pair of re-used west doors to the Galilee are illustrated and described on p. 97. The door giving access to the vestry has saltire-ledging on its rear face that is fitted into the edge-timbers by means of assorted lap-joints—some being barefaced lap-dovetails, and others

being, apparently, square-ended laps. The frontal face has fillets with hollow-chamfered edges placed vertically, so as to cover the joints of the seven planks. This must be of the Perpendicular period, but it is felt that it must also be early work for that period—illustrated in Fig. 113. The roof of St. Catherine's Chapel is described under apse roofs on pp. 65–6.

The roof to the north transept triforium, to the east, is illustrated in Fig. 114; this is apparently of the eighteenth century and of interest.

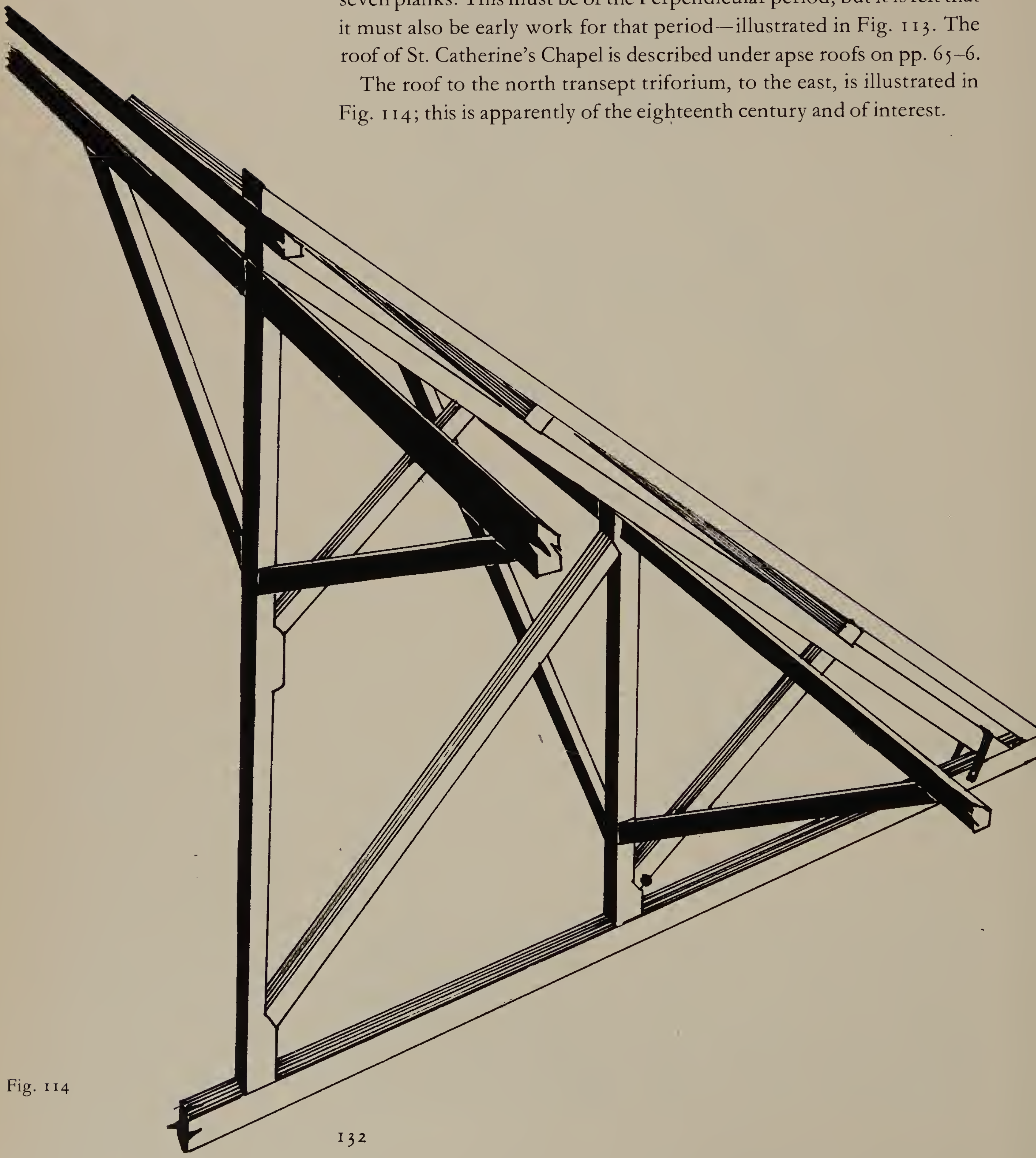


Fig. 114

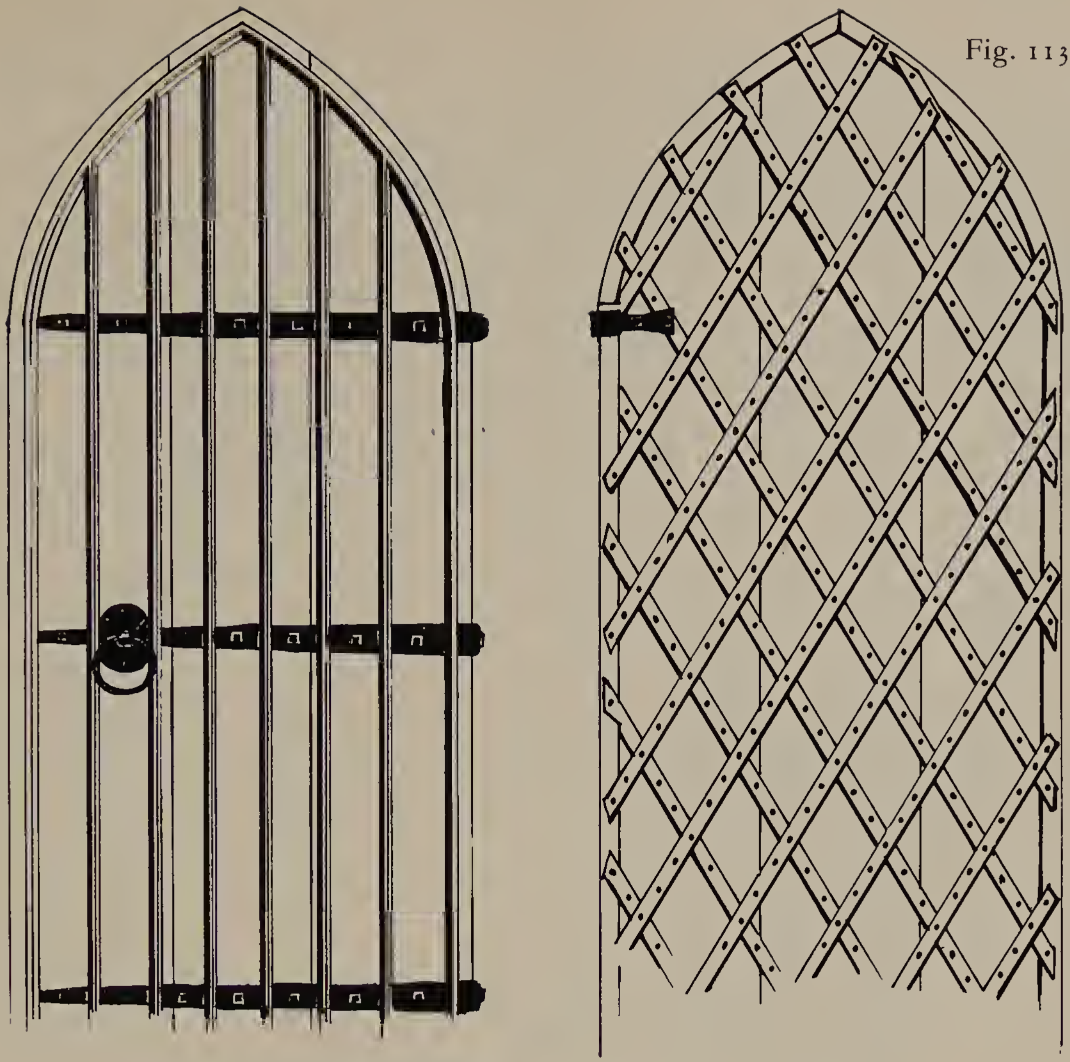


Fig. 113

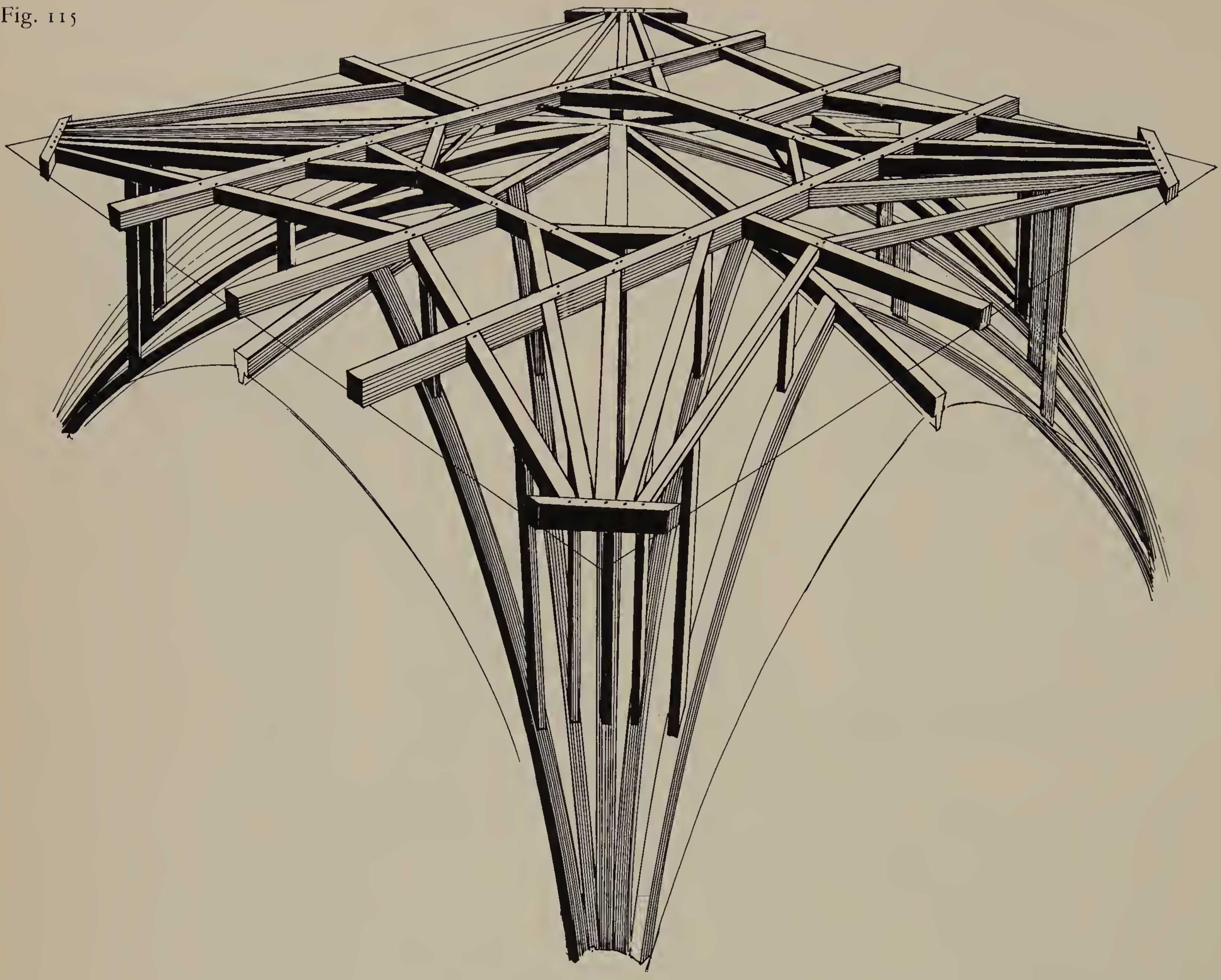
Exeter Cathedral

Relevant building-dates: 1133—the flanking towers
1288–1308—presbytery
1308–17—crossing formed
1353–69—nave vault

The very long high roof over this cathedral is apparently of three main phases of building, as quoted in "Ridged Main-span Roofing" (p. 25); altogether the sequence of rafter-couples showing—as they do—gradual modifications together with visual relationship to others are of great interest and importance. The main building-dates are given on p. 25, and the frame-designs are illustrated in Figs. 13, 14 and 15.

The timber vault to the south transept is illustrated in Fig. 115. The date of this is, I am assured, absolutely precise: 1317. As shown in the diagram, the rib-timbers are supported by two vertically placed scantlings tenoned at tops and bottoms; this appears to constitute a development from the diagonally supported ribs at St Albans, which has an older timber vault. The floor from which this vault is hung must date from the same building operation since it is framed into a square, central void, through which the vault's crown rises. The profiles of the ribs

Fig. 115



cannot be seen from above or beneath. Both towers contain early roofs, and the west front has two interesting pairs of doors: at the north, and at the central opening wherein they have quatrefoiled face-timbers.

The chapter house has a fine open roof with flattish pitch and traceried voids in each truss; the wall-piece and arch-brace voids are also traceried, three purlins in each slope; finely painted. This roof has been sensitively restored recently, and is suspended from above. It possibly dates from 1413–39, when John Harvey records work was effected on the upper part of the chapter house by John Tynlegh and John Harry.

Gloucester Cathedral

Relevant building-dates: 1450–60—central tower
1457–83—lady chapel
1381–1412—cloisters

The floors in the central tower are most impressive. One of these is shown in Fig. 116; datable as the tower, 1450–60.

The high roof of the lady chapel has short king-posts, lap-dovetailed to the tie-beams and housing the ridge-piece, as at Bristol's choir-roof. This in all probability dates from the building of the chapel. The side-purlins *may* have their soffit-shoulders housed, but this is uncertain.

The transept roofs, shown in Fig. 117, are of interest.

The south doors, of Norman shape as is the doorway, are built of planks crossed at right angles, and bear ironwork of Norman style and date.

The cloister doors, shown in Fig. 91, are of interesting shape and finely traceried. They are described and illustrated in the chapter on cathedral doors, pp. 98 and 101.

The nave triforium lean-to roofs are medieval, much repaired, but not examined.

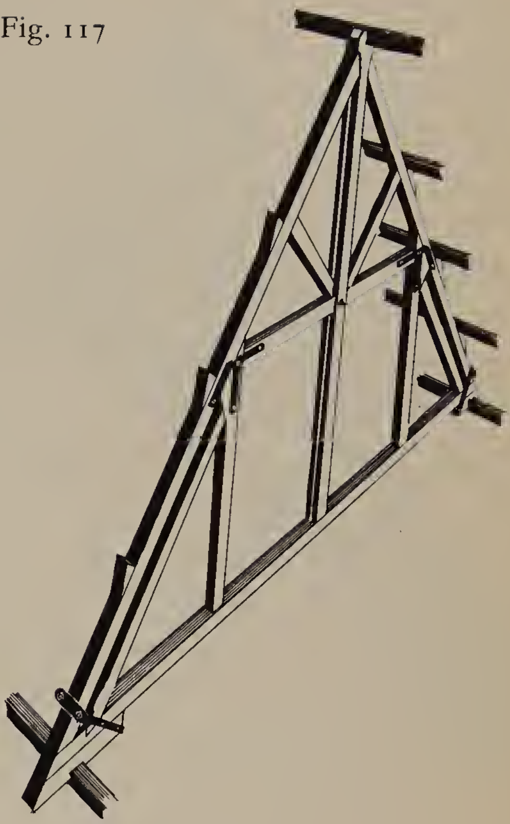


Fig. 117

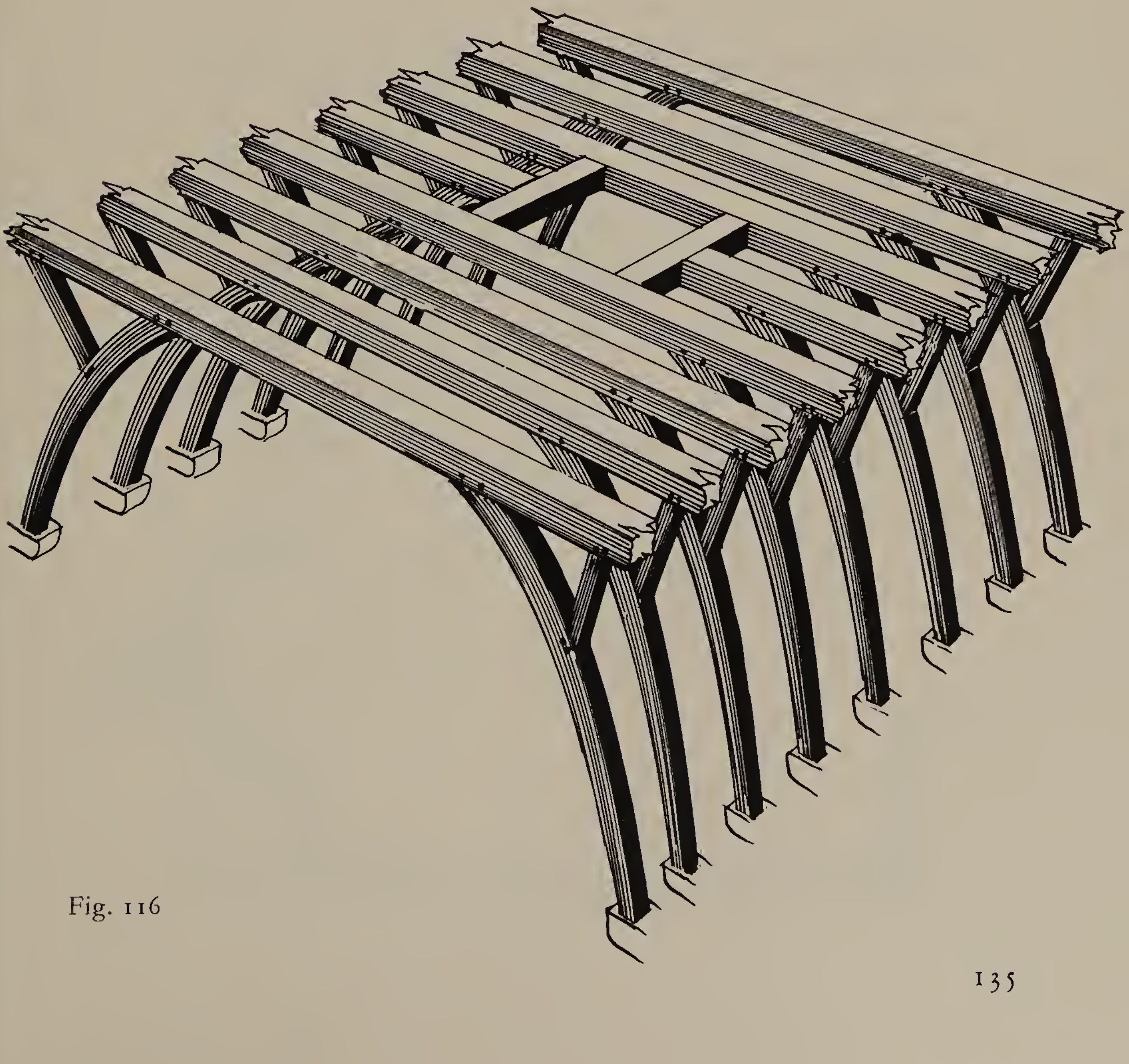


Fig. 116

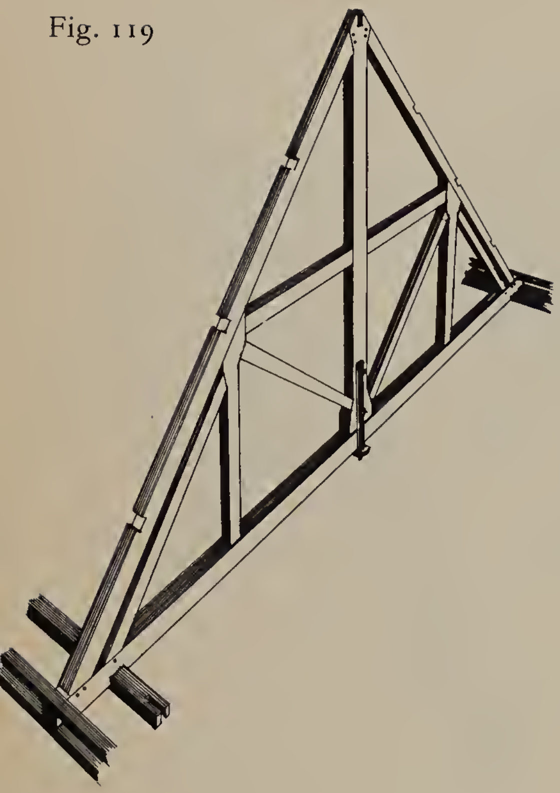


Fig. 119

Hereford Cathedral

Relevant building-dates: 1412–18—cloister (part)

The roof of the cloisters is described on p. 43 and illustrated in Fig. 31. Early fifteenth century.

The cloister door is extremely good; it is described on p. 98 and illustrated in Fig. 90.

Lady chapel high roof, an interesting variation of scissor-bracing, is described on p. 41 and illustrated in Fig. 29.

The south-east transept has a high roof of interest and probably of sixteenth-century date, with later purlins. This has four low-pitched frames, having three raking-struts each side of their centres, laid across a timber mounted on short posts which stand in the pocket between the four vaults, which intersect. This is illustrated in Fig. 118, and the details of its jointing are there shown enlarged.

The south transept has a king- and queen-post roof, illustrated in Fig. 119. Little ironwork was used upon it. The chancel high roof is very similar. The north transept has a king-post, raking-strut and queen-post with secondary-rafter roof, one frame of which is dated 1852, the year of restoration by Cottingham. The nave roof is of the same type.

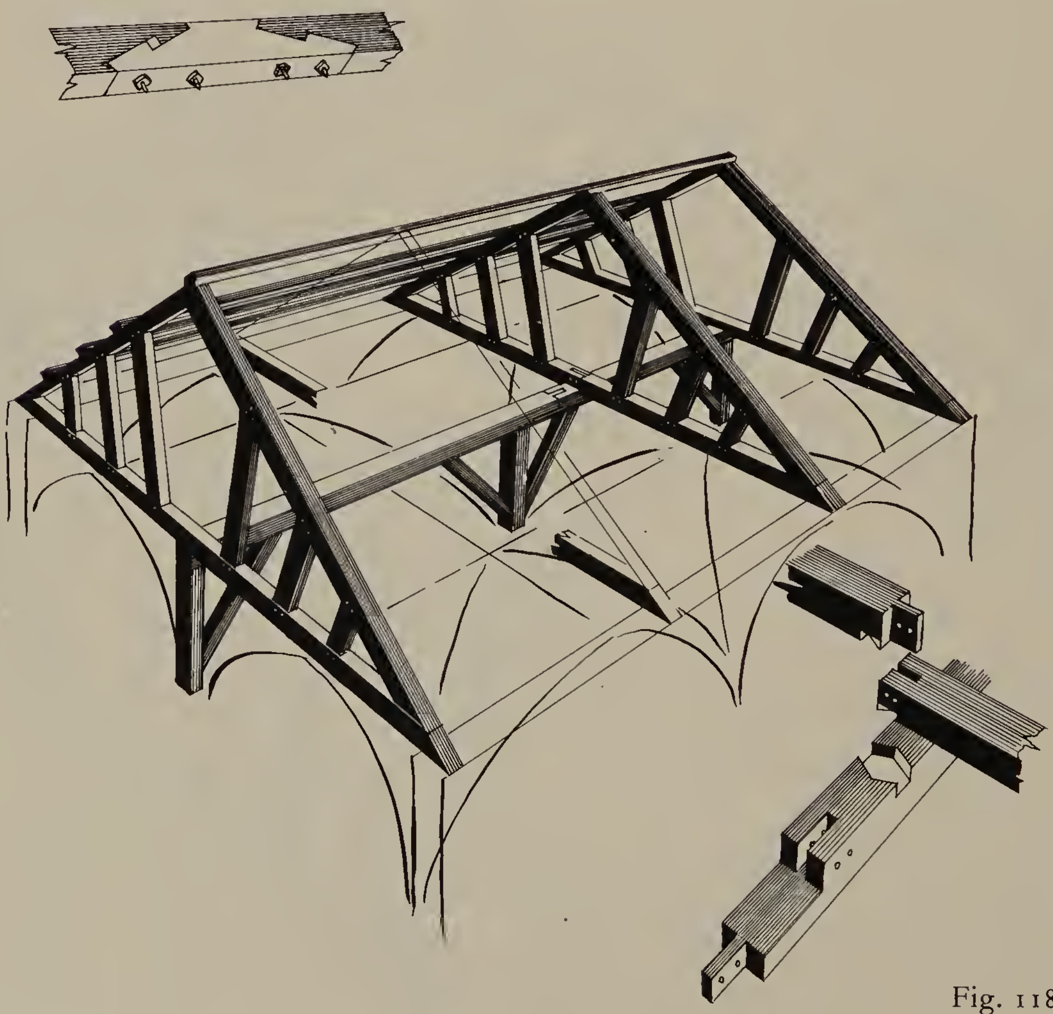


Fig. 118

King's College Chapel, Cambridge

Relevant building-dates: 1476–85—five eastern bays roofed
1510–12—western bays roofed by this time

The high roof, which is in two distinct "builds", is illustrated in Figs. 32 and 33; the whole is described on pp. 43–5.

The "jib" of a hoisting device exists, apparently contemporary with one of the building operations; see pp. 71–2 and Fig. 59.

The doors are of interest, the western pair being dated to 1614–15; and the northern doors are of the early sixteenth century (shown in Fig. 120).

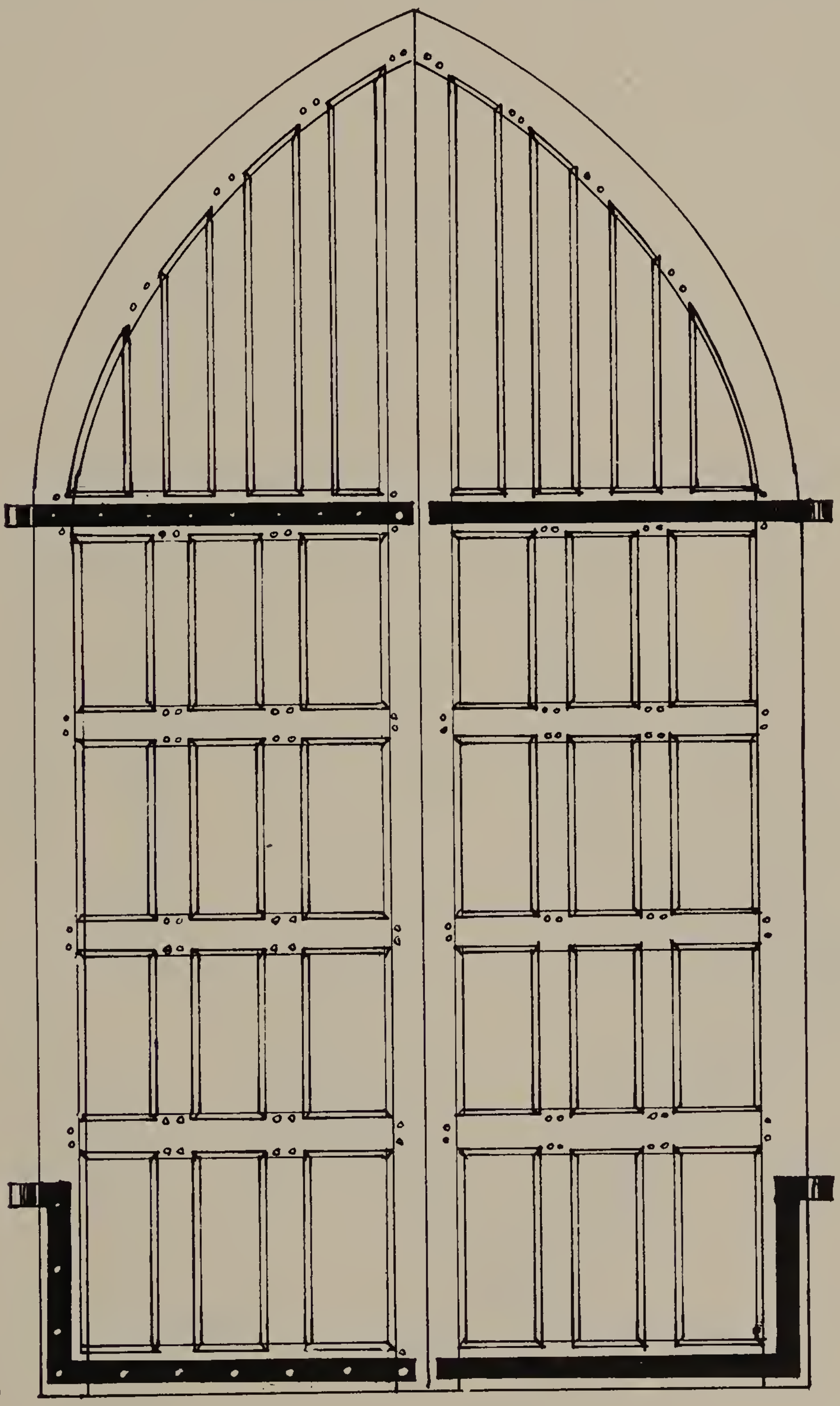


Fig. 120

Lichfield Cathedral

General restoration: 1661–9

The retro-choir high roof with apse is simply contrived, and this is described and illustrated on p. 66 and Fig. 53. One bay of the high roof over the southern transept, that at its northern end, is shown in Fig. 121, together with the tie-beam seating-joint, enlarged at the lower right of the drawing. This is essentially the roof-type used throughout the general restoration, with some subtle variations, often of jointing alone. Common collars occur in some bays in each arm of roofing, and the eaves-bolts at Lichfield are forelocked at that late date. The lean-to roofs are of twice-used timbers and are of little interest except as evidence for possible conjectural restorations of former designs.

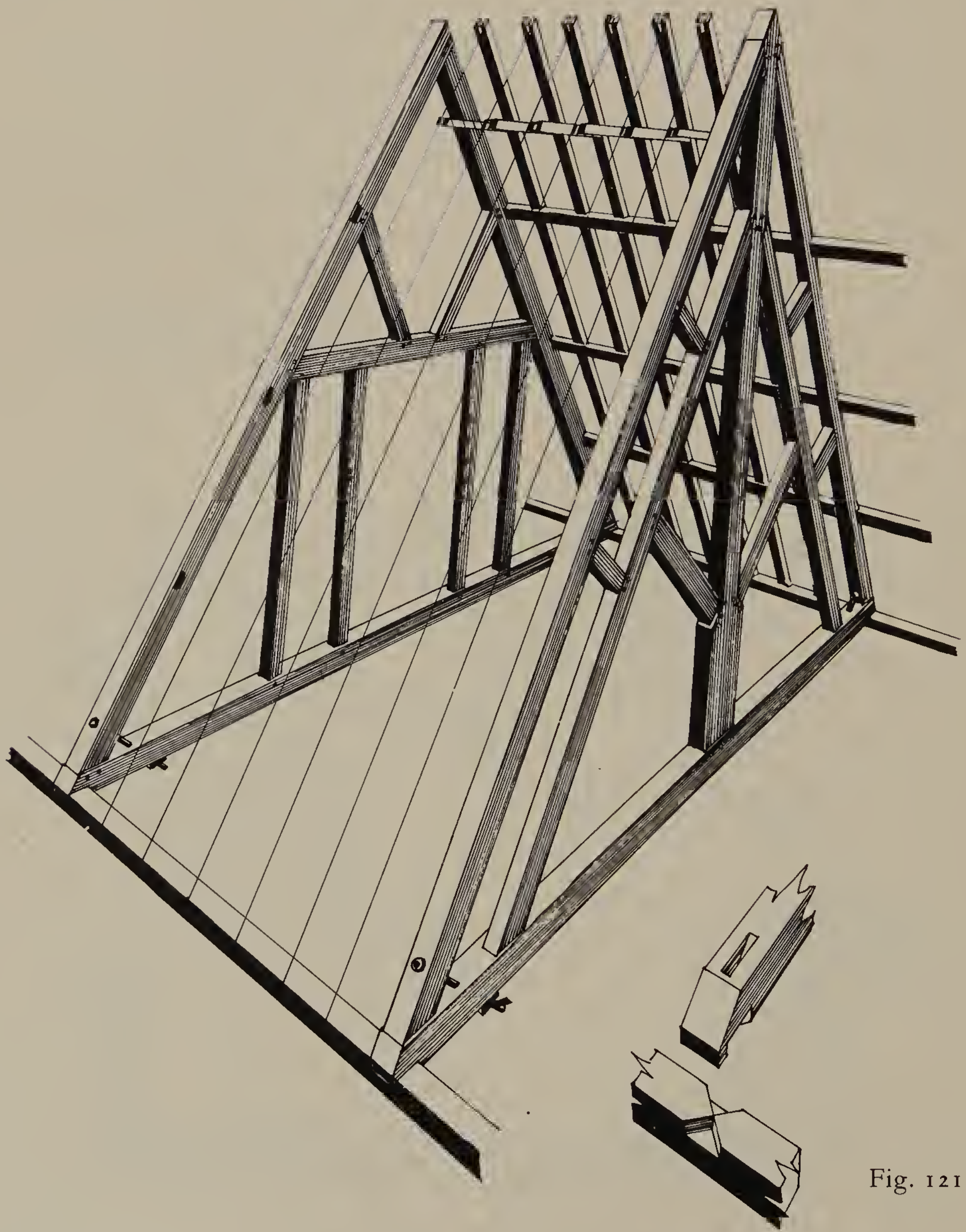


Fig. 121

Lincoln Cathedral

Relevant building-dates: 1192–1200—choir and east transepts
c.1200–20—great transept
c.1220–35—chapter house
c.1225–53—nave
1237—central tower fell
1256–80—angel choir
1295—cloisters
c.1335–40—south transept: gable

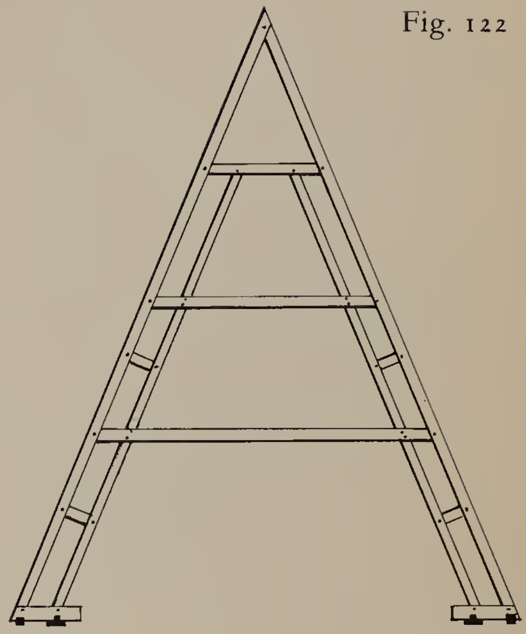


Fig. 122

At the time of writing all the carpentry at Lincoln is of supreme interest and importance for the study of developments, the high roofs constituting a series that coheres. Only the examples not previously mentioned will be described at this stage, and of these the high roof to the south-west transept is of greatest interest. This is shown, as a single transverse frame, in Fig. 122. Tie-beams were fitted in this case at every fourth successive couple, and the whole stands on double wall-plates of which the internal pair have face-fillets to locate the sole-pieces—a practice much advocated during the thirteenth century. The couples have three collars each, but the diagonal struts and ties, or "laces", are in this roof omitted, while the secondary rafters that double the feet in the previous roofs are extended

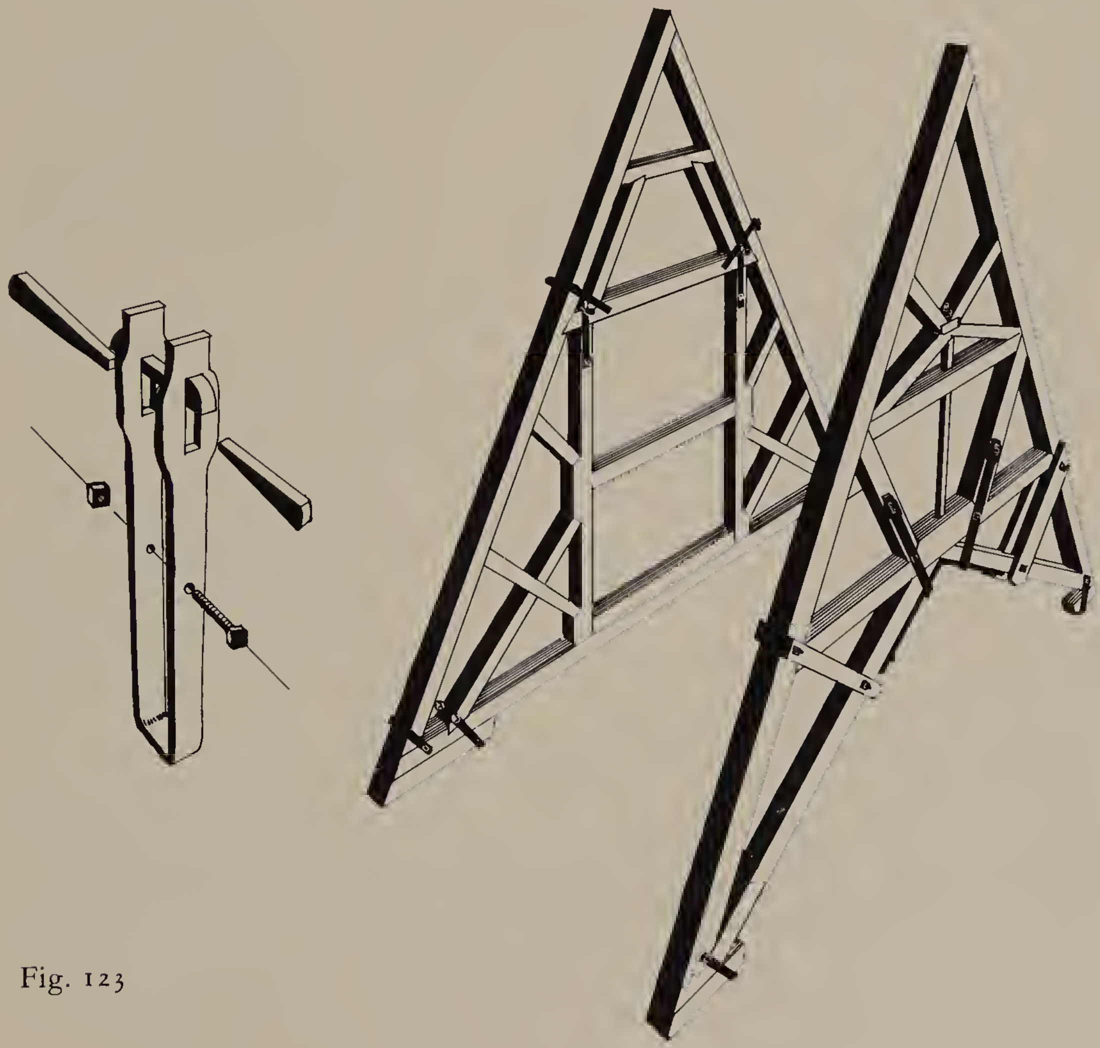


Fig. 123

and reach the height of the upper collars. This framing is further stiffened, laterally, by the fitting of struts at the centres of its longest double rafter-lengths. The resulting design closely resembles that of the midstrey-roofs at the Abbot's Barn, Glastonbury.[82] It would seem probable that this roof may date from the building of the transept's south gable *c.*1335–40.

Not previously mentioned, and of great interest, is the framing of the roof intersection formed by the eastern transept and the choir. This is not illustrated but is effected by setting three couples in each arm on valley-rafters, their collars rising in height toward the apex of this crossing.

Of great interest with regard to post-medieval studies is the high roof of the north-west transept, which is of softwood very much augmented by ironwork. This is illustrated in Fig. 123, which shows two types of its frames together with one of the cottered stirrups used. The bolts in this roof are screw-threaded, and the date of the restoration by James Essex, in 1762–5, may be a likely one for this work; but the quality is superior to Essex's work at Ely. This roof has common-purlins too.

The roof subsequently elevated into a spire is illustrated and described

Fig. 126

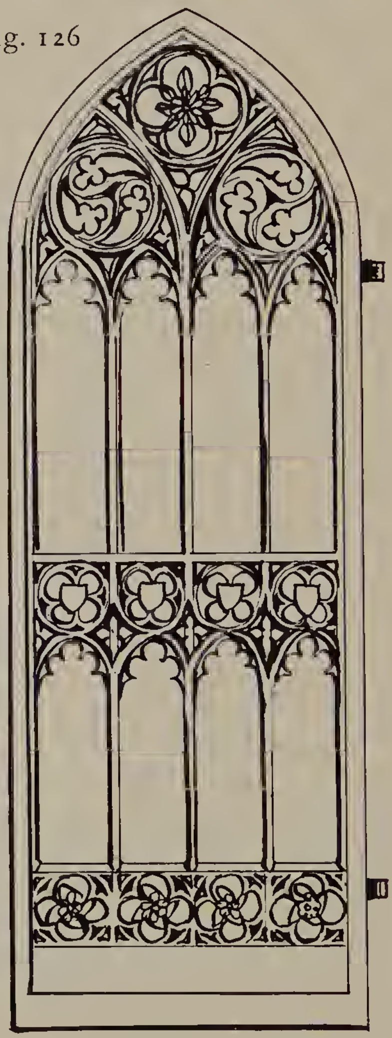
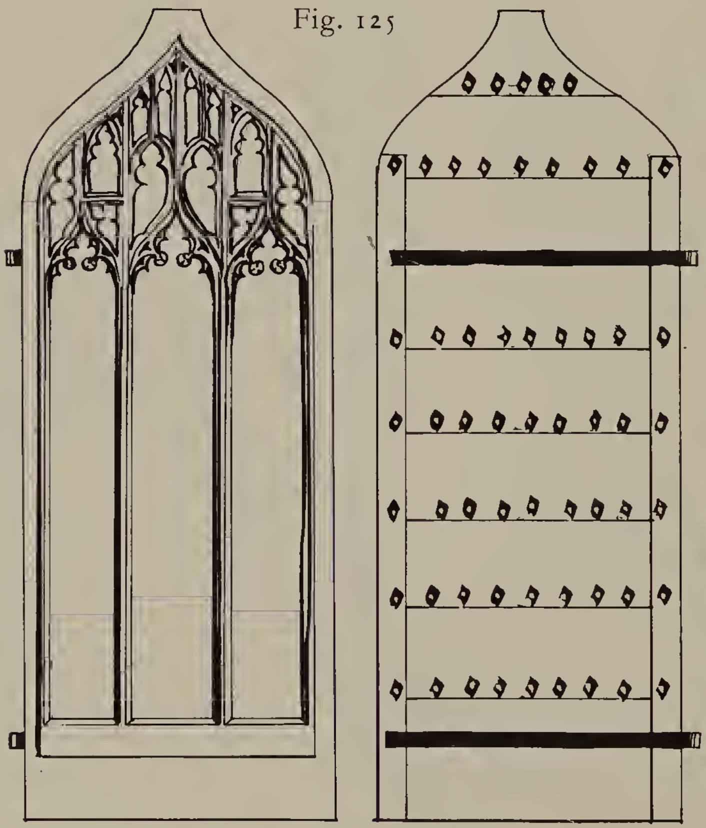
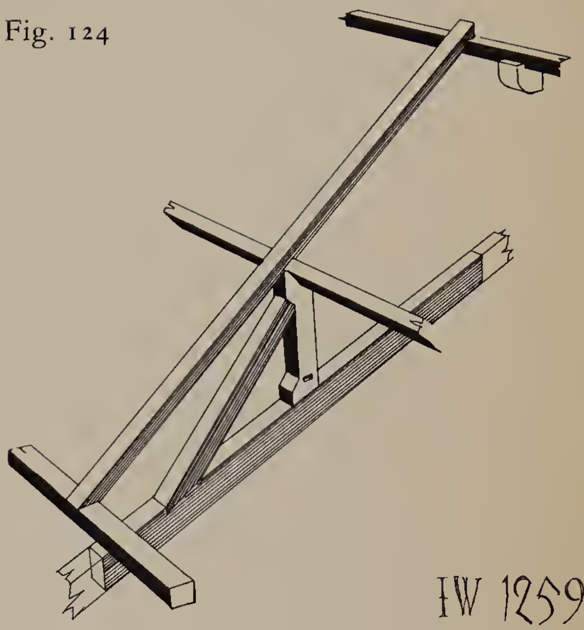


Fig. 125



on p. 81, under "Chapter Houses". The lean-to roofs of the Cathedral are of various types and ages, and a finely wrought example of the eighteenth century is that over the north nave triforium, which is illustrated in Fig. 50 and described on pp. 61–2. The eastern triforium of the northern arm of the great transept is roofed with a construction dated "I W 1759", which is illustrated in Fig. 124. This appears to be the earliest example in this series having a trapped nut, in a mortise, for a bolt set in the centre of a post. At the eastern side of the choir transepts are four apsidal chapels, one of which has a roof with king-posts, raking-struts and butted side-purlins; this is of very low pitch and could be of great age—a carbon date would be necessary in this case since insufficient structural evidence exists to date it.

Fig. 124



A lean-to roof of "vernacular" character exists over the southern triforium, between the main and choir transepts of the nave. This is not illustrated, but is low-pitched and has arris-, or diagonally set, purlins that are tusk-tenoned through the principal rafters. This is entirely of pine, and a late eighteenth-century date is possible for it. The roof over the northern triforium of the choir is illustrated in Fig. 41 and described on pages 51–2.

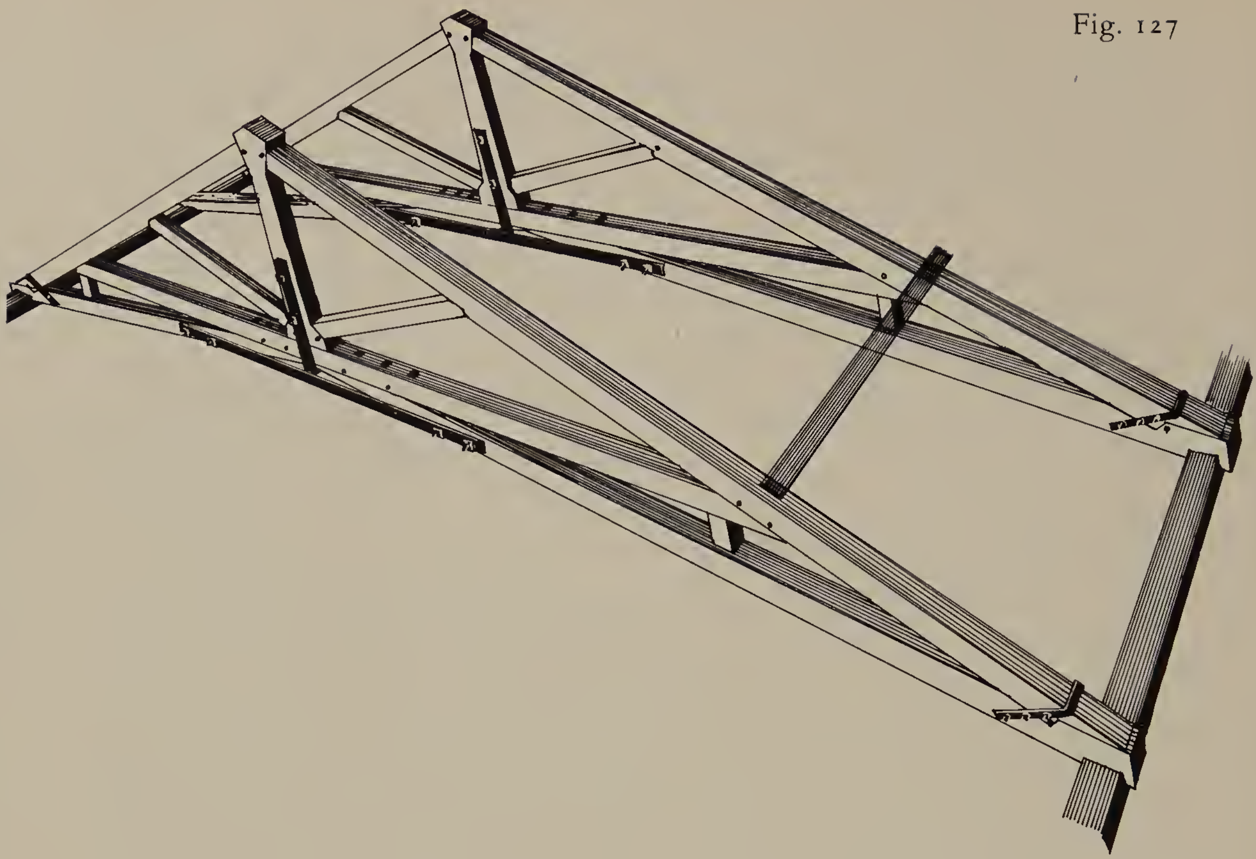
Most of the doors at Lincoln would repay very detailed study, and the central pair in the west front are interesting, but unlikely to relate to the date of that front, although a firm date cannot be ascribed upon the basis of any structural evidence. The tall and narrow pair of doors at the southwest of this front are equally undatable. The very fine doors leading into the cloisters are described on pages 97–8 and illustrated in Fig. 87. Another pair of doors, opening southward from the Angel Choir, are rectangular beneath a plate-tracery head and retain their vertically positioned locking-timber with an iron top-socket and a hole in the paving for its base. Smaller doors inside the Cathedral are those giving access to the Fleming Chantry of 1452–83 and the Russell Chantry of 1480–94. The latter has tracery of very good quality, and both are illustrated in Figs. 125 and 126 respectively.

London: St. Paul's Cathedral

Building-dates: 1675–1710

The high roof over the nave is illustrated in Fig. 36 and described on page 47, but those frames of that roof that surmount the west portico above the steps are more interesting and are also illustrated, in Fig. 127. These are raised upon elaborately "built" ties that have rising soffits and pendant king-posts with raking-struts. No failures were noted either of jointing or of ironwork at the time of my examination. The carpentry of

Fig. 127



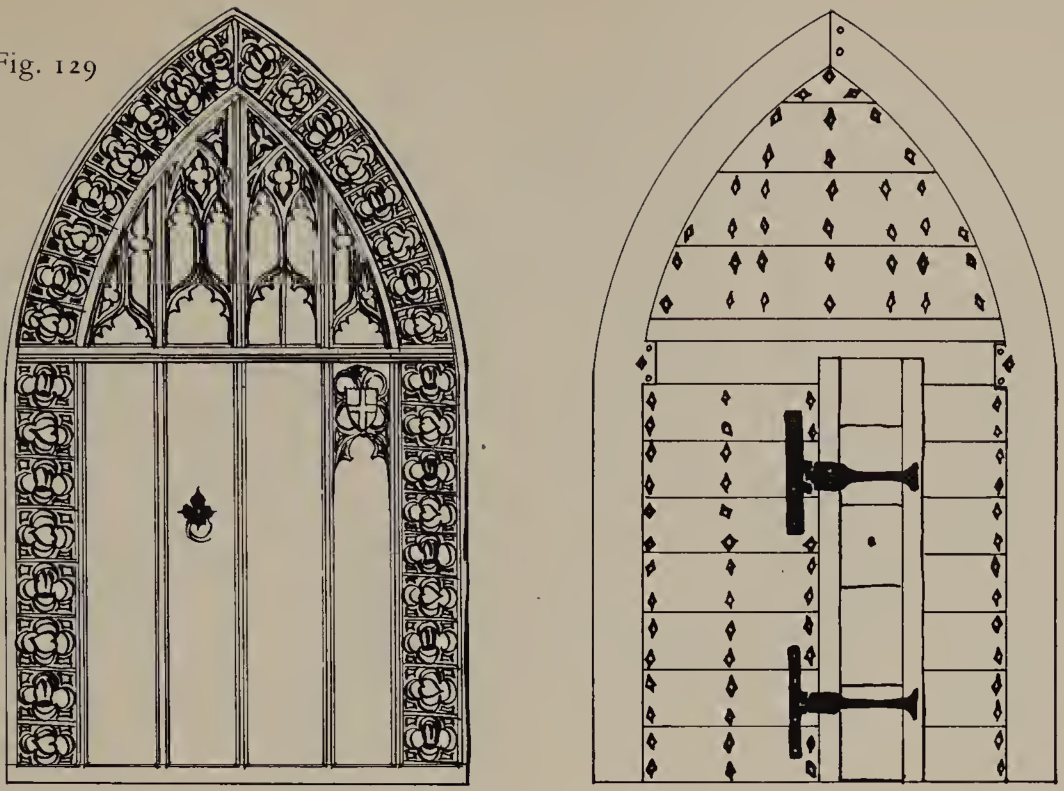
the "drum", as it is called, is equally good, but is not illustrated; this roof is framed upon alternately radial frames, and frames that branch into triangular units—on plan. The normal lean-to roof-type is illustrated in Fig. 49, and is described on pages 60–1 under "Lean-to Roofing". The frames forming the wooden, external dome are impressive, but have often been illustrated, hence omitted. The main ribs of this wooden dome are scarfed at about their centres—of length—and must in all probability have been bent into their present shape, by the use of one of the then current shipwrights' methods. The cladding of this dome is borne on horizontal timbers that approximate to common purlins. Many, if not all, of the doors of this cathedral would repay study—none are illustrated herein.

Norwich Cathedral

No relevant building-dates known.

The high roofs over the vaults of the choir, nave and transepts at Norwich have all been replaced during recent years, and only one medieval lean-to roof now exists—which has been illustrated and described in Fig. 47 and on page 58. The hoisting device, now in the spire, where it has been since the eighteenth century, is illustrated on page 72, and has also been described. What remains, for this appendix, is the timber reinforcement built within the stone spire which was by Robert Everard, and of the years *c.*1464–72. According to J. A. Repton,[83] much timber framing

Fig. 129



was introduced to strengthen this spire during the times of J. Turner the Dean, and also during the times of his predecessor—that is, in the second half of the seventeenth century. It is most valuable to have this firm dating, since this woodwork is not, on sight, of a type that many would ascribe to so early a date; its various lapped joints, barefaced dovetails among them, are nailed through. Some of its sub-structure is older, but probably not original, and some floors with their joists may be original. All this is material for further study.

The high roofs formerly existing over the four main arms of the Cathedral were scissor-braced but, according to the scanty records produced at the time these were removed, all were of the same construction, employing some halved and many chase-tenoned joints. A dating for these roofs can now be no more than conjectural, and will be omitted since they no longer exist.

A very pleasing pair of half-doors exist in the south aisle choir-screen, of which the left-hand door is shown in Fig. 128. These are not firmly dated to my knowledge. The central pair of doors in the west front is also good, and could date from the fifteenth-century work that inserted windows in that front. All the rear timbers of these doors are hollow chamfered. The doors to the St. Martin's Palace Gate are extremely fine of their kind, in fact the finest of that kind; and the larger pair were shown in Fig. 92, under "Cathedral Doors". The smaller pair in this gateway are shown in Fig. 129, and rival the larger ones in richness. The very small single door for general use is contrived as one of the face panels, and has a heraldically decorated head to it.

Fig. 128

Oxford Cathedral

Relevant building-dates: *c.*1350–5—Latin Chapel

The open timber roof of the nave has already been dealt with on pp. 34–5, and so has the high roof over the Latin Chapel on p. 38. This leaves the open roof of the north transept, which is in the style of the Perpendicular period but of uncertain date. It is camber-beamed and in three bays, having side-purlins, it is too high and dark to interpret its mouldings. There is also a high roof over the lady chapel which is of "vernacular" type. This is in five bays, and has two side-purlins each slope, the purlins being butt-fitted, and the lower ones having curved wind-braces—of approximately four-centred arcature. Possibly of the sixteenth century, or a little earlier. An ancient roof of timber also survives above the stone vault of the chapter house. I was not able to examine this, but Mr. J. H. Harvey considers it possibly of the thirteenth century.

Peterborough Cathedral

Relevant building-dates: *c.*1155–75—nave
*c.*1193–1230—west front

The fragmentary roof over the north-west portico, the central western doors and the windlass have already been described, on pp. 17, 94 and 69 respectively. The southern pair of doors in the west front are also worth a very close study, and have most interesting ledging and a carved wooden capital on their central "shut" timbers. The timber ceiling of the nave is datable to the close of the twelfth century, and claims to be the longest of the kind in Europe; this no longer relates to the high roof above, but some evidence survives to assist a theoretical reconstruction, since some of the beams are original. The doors to the western porta of the precinct have also been described, on page 90, which date to 1177–94, in the episcopacy of Abbot Benedict. Many conventual buildings remain within this precinct, of great interest and early dates.

Other fragmentary roof-frames exist, combined into one roof over the south-western portico, with some highly interesting and late scarfs.

Ripon Cathedral

Little medieval carpentry remains at Ripon, but the existing roof over the choir is impressive, among softwood and iron examples; this is illustrated in Fig. 130. The iron straps and spiders used in this are galvanised, and so can only date from after the invention of that process in 1742. It was patented in 1836, after which date this roof is most likely to have been built. The whole is designed with a wooden "vault" beneath, and

Fig. 130

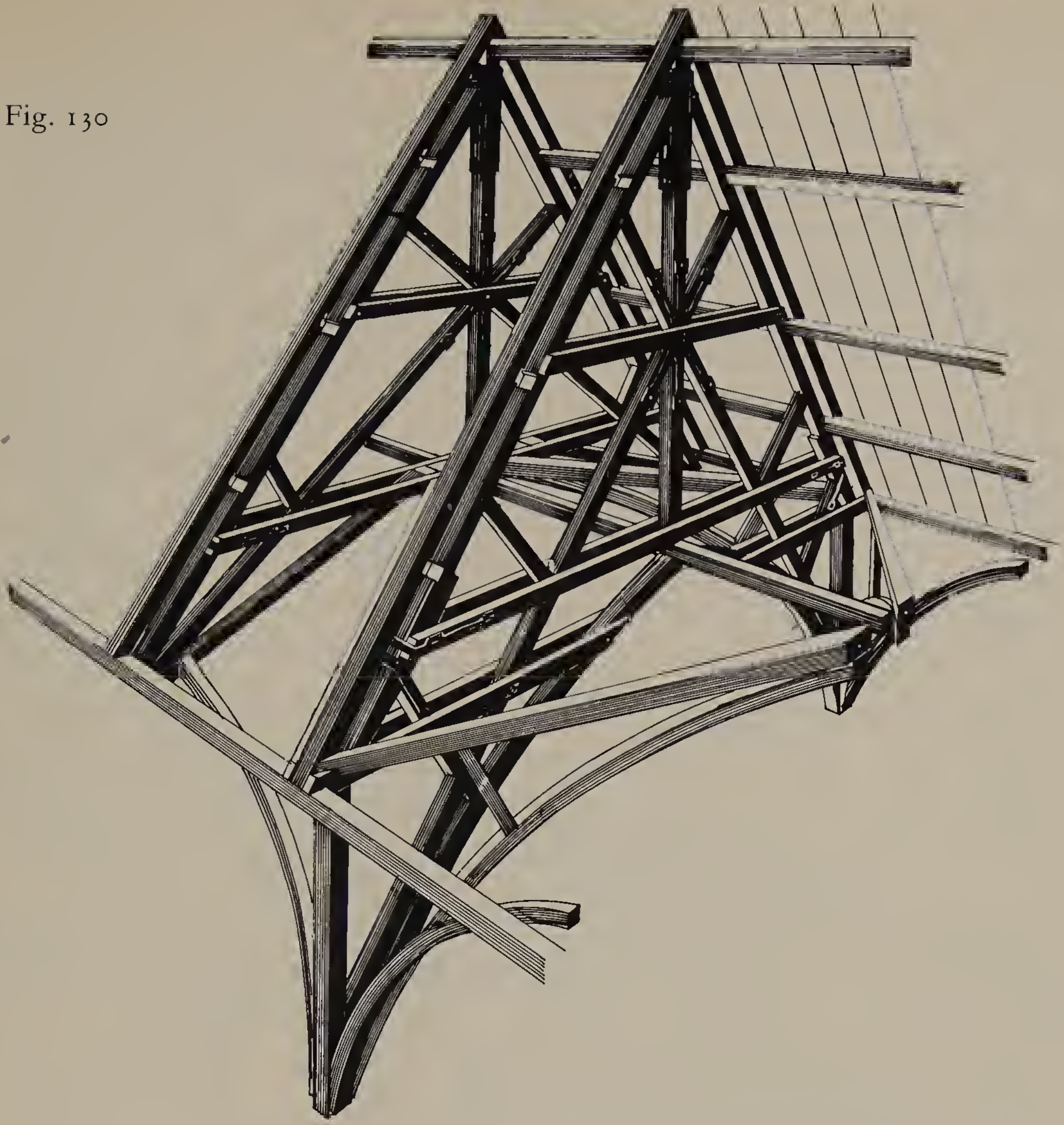
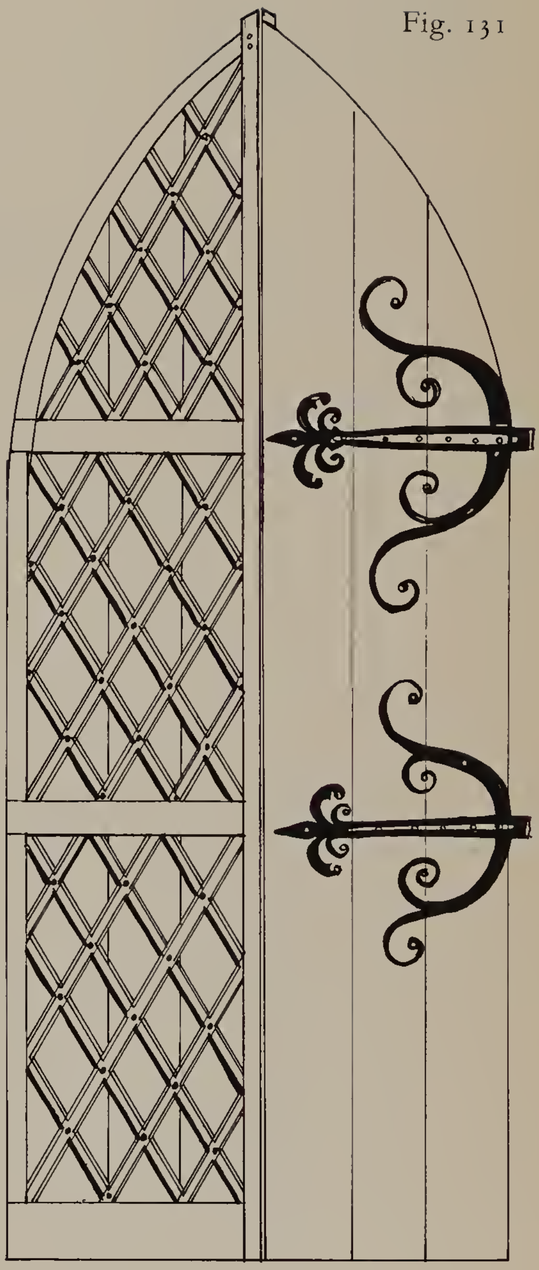


Fig. 131



is a development from the scissor-braced roof, having king-posts designed to intersect the intersections of the scissors; and sometimes collars intersect this complex again—producing an eight-armed star of timbers. It will be of great interest, for posterity, to check the length of the life of this roof, in view of both its ingenious design and poor materials. What may well be a very late medieval roof, of low pitch, heavy timber and simple frame-design is that partly surviving over the vault of the north transept. This is not illustrated, but clearly would repay much further study. It is a tie-beam design with huge oaken ties that are well cambered, on these principal rafters of massive section, with straight collars equally heavy; and two side-purlins per slope. The only possible date mark is the form of tenons used for the purlins; these are central with housed soffit-shoulders—typologically preceding those with diminished haunches; and of *c.*1490–1525.

The pair of doors leading from the northern transept into the choir aisle appear to be of the Early English period; these are illustrated in Fig. 131. They are saltire-ledged and have very good, restrained, iron rides—shown on the right of the drawing. The central doors of the west front were evidently re-faced in 1673, that date being studded in iron

spikes upon them; their rear frames are saltire-ledged and their arcature approximates to that of the Decorated. It is possible that part at least dates from the building of the present west front *c.*1230–40.

Rochester Cathedral

Relevant building-dates: *c.*1322—south choir aisle
1871—restoration by Cottingham

The high roofs over the northern main transept, and the southern choir aisle have been described (pp. 49–50, 54–5) and the high roof over the choir remains—which is shown in Fig. 132. This is a roof-design compelling admiration, but possibly it is too elaborate to be fully justified. As shown in the drawing, it combines many elements normally found sufficient in their own right into one single design. These are king-pieces set at the apexes, arches to above collar-height, scissor-braces and radial ties which combine principal rafters with arch-timbers and scissor-braces. The arch-timbers are of oak, the remainder of pine. These are frames incorporating many excellent jointing devices.

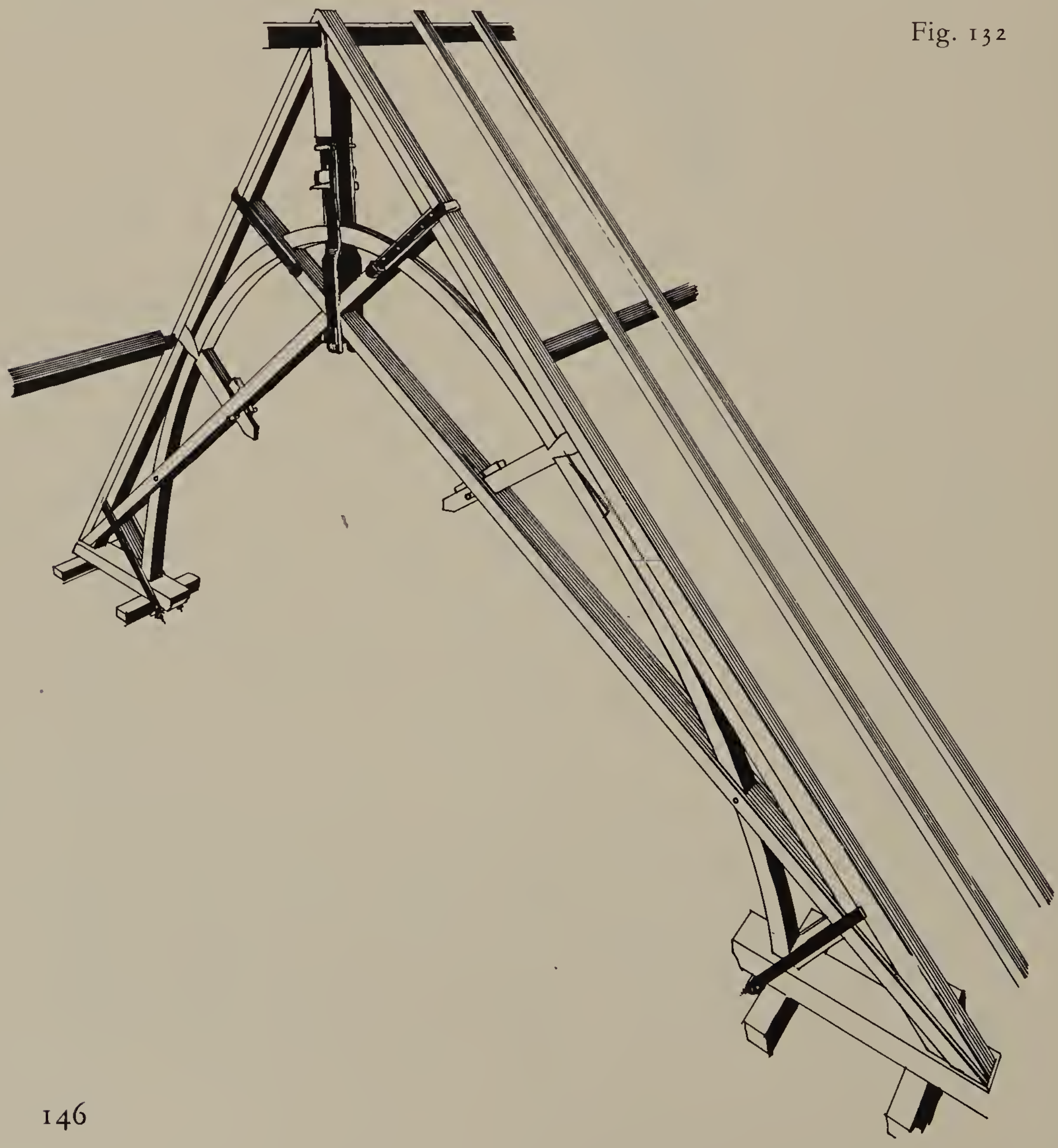


Fig. 132

St. Albans

Relevant building-dates: 1260–*c*.1290—presbytery, timber vaults

Timber work not previously described includes the floors framed into the crossing tower, which are not illustrated; these are medieval and merit further study—some octagonally sectioned posts exist below the bell-chamber set in fairly complex framing. This is likely to date from the fifteenth century.

Two of the doors belonging to the west front before its restoration by Lord Grimthorpe have survived, and stand in the northern transept; this is curious since they are so vastly superior to their later replacements. One of these is illustrated in Fig. 133. They are apparently of laminated construction being only three and a half inches in thickness. They do not seem to be dated.

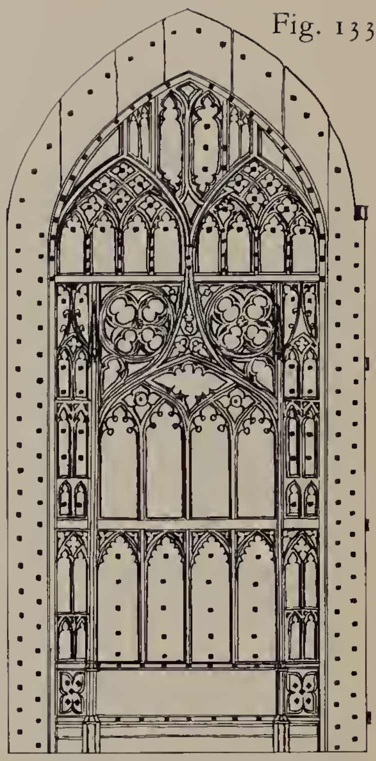


Fig. 133

Fig. 134

The Abbot's Door is described on page 98. The timber vault of the presbytery is the oldest of the kind in England and is shown in Fig. 134, together with the profile of its rib-timbers. This is diagonally supported from posts that formerly might have been components of the high roof, now missing. The whole was sensitively restored and would repay exhaustive study.

Salisbury Cathedral

Relevant building-dates: 1237–58—choir
1237–58—great transept, nave
*c.*1258–66—west front
*c.*1275—chapter house
1334–*c.*1380—tower and spire
1787–93—alterations by James Wyatt

Much important carpentry remains to be described with regard to this cathedral, and these items are taken from the high level first, down to triforium, and then to doors at ground level. It would seem that Wyatt

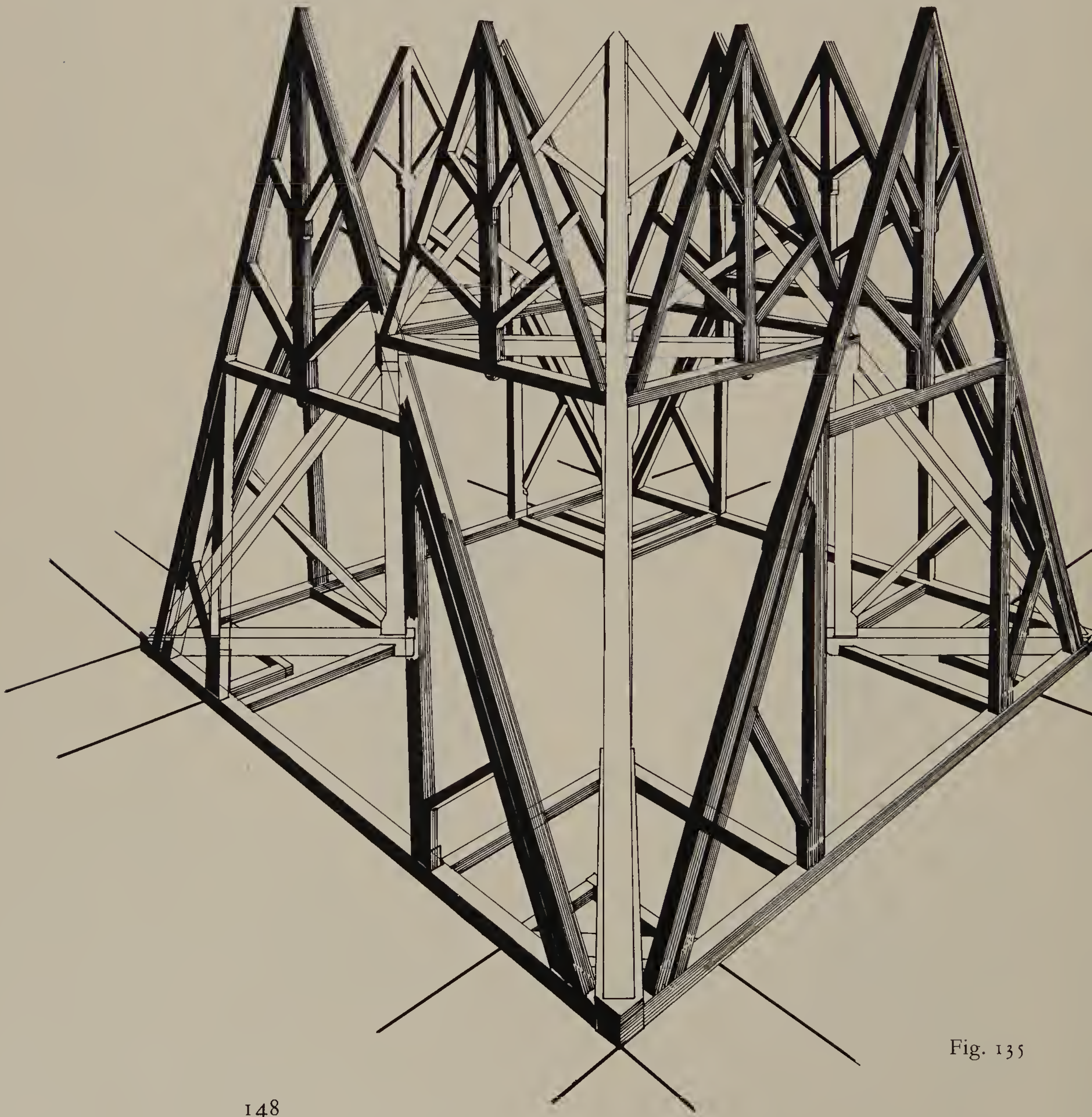


Fig. 135

must have been responsible for much of the later roofing, some of which bears dates within his period of activity at Salisbury. Most impressive of these later works is the crossing of the choir high roofs—which is illustrated in Fig. 135. This is too complex, when viewed from an angle, to show all timbers, and so some are left lightly indicated for clarity. The basic frames are queen-post with secondary rafters and raking-struts, while above the collars are king-posts with two pairs of raking-struts—simple enough so far. At the point of the choir crossing, where four such series of identical frames intersect at right angles, framing becomes a little more complex. As shown in the drawing, the outer wall-plates are framed into the overall square having a fully framed roof-truss standing on each of its sides; from its corners dragon-beams cantilever into the square, having four queen-posts standing at their inner ends, over which are laid four valley-rafters. The whole is fully framed in the same manner as are the roofs of the four arms, and a king-post set at the centre of the crossing is raking-strutted to the valley-rafters; while complete king-post trusses stand upon each of the four "internal" collars. The roof planes are made up with common purlins. This is, in fact, two centrally intersecting and identical roof-trusses, set up along the diagonals of the square first formed. One timber is inscribed: "Jas LARKIM 1780", an unknown who may have worked on the Wyatt alterations. Forelock bolts are used in this design.

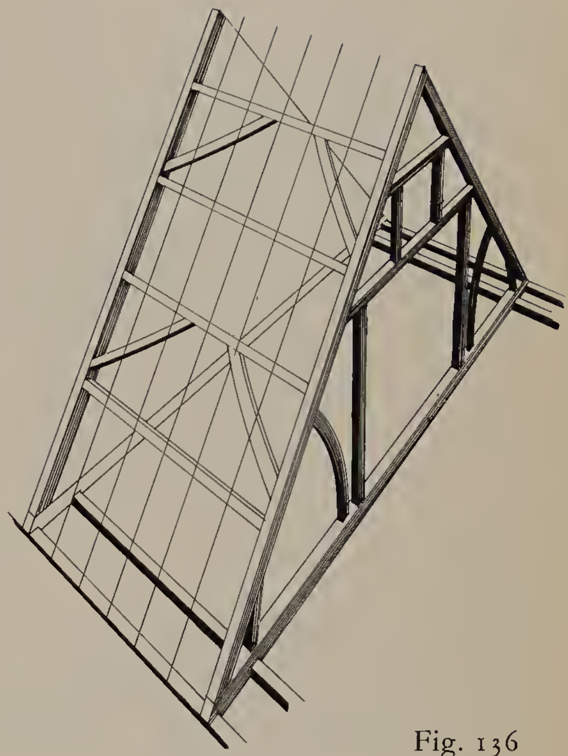


Fig. 136

The high roof of the nave is largely built from earlier, oaken timbers, and may be of the mid- or late seventeenth century. The frames of this are queen-post and collar, with smaller queen-posts and a high-collar set upon the first; four side-purlins each slope and no ridge-piece. Double wall-plates are provided, and inclined ashlar-pieces having housed and spiked head-joints. One bay of this is diagrammatically shown in Fig. 136. Twenty of these frames exist.

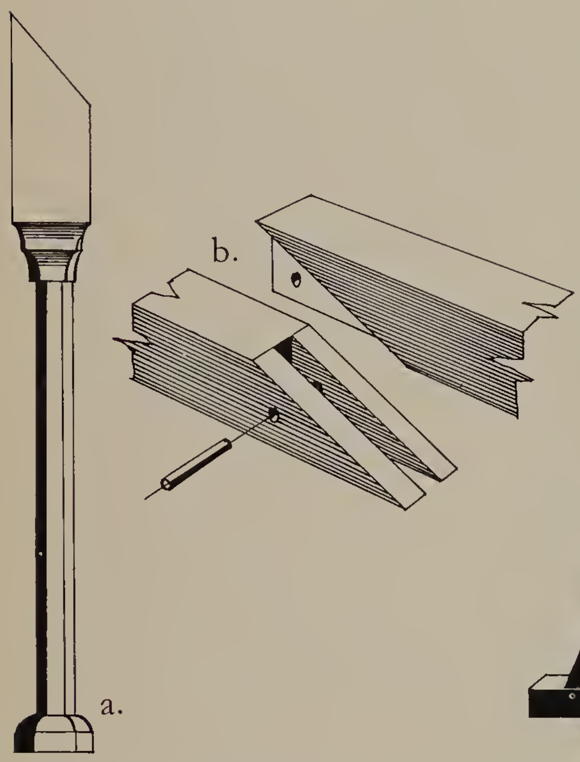
The two chapels east of the choir's eastern end both have simple roofs of seven cants with cambered tie-beams—entirely of oak and contemporary with the chapels.

The framing of the angle formed by the north triforium and the north great transept triforium is illustrated in Fig. 137. In such cases as these drawings completely beggar verbal descriptions, and the least said the clearer—perhaps. The drawing is as viewed from outside the angle of the eaves of the whole, and the hatched timber ascending from lower right to top central is the valley-rafter. A very few "secret" notched lap-joints are used in this assembly, at the tops of the secondary rafters and one of these is showed as an "X"-ray at lower left. The formation of the angle between the northern nave triforium roof, and that of the north porch, or

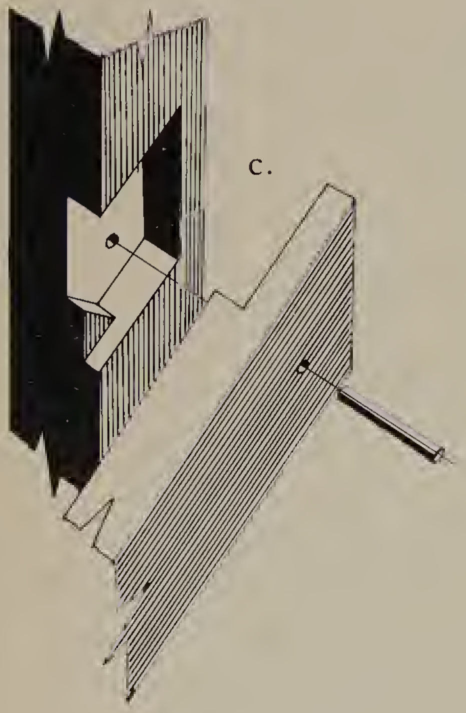
Fig. 139
Salisbury

a. Post supporting valley-rafter in triforium angle.

b. Triforium lean-to roof, purlin scarf; bridled with through-splayed shoulders.



c. Secret notched-lap joint, used for secondary-rafter tops.



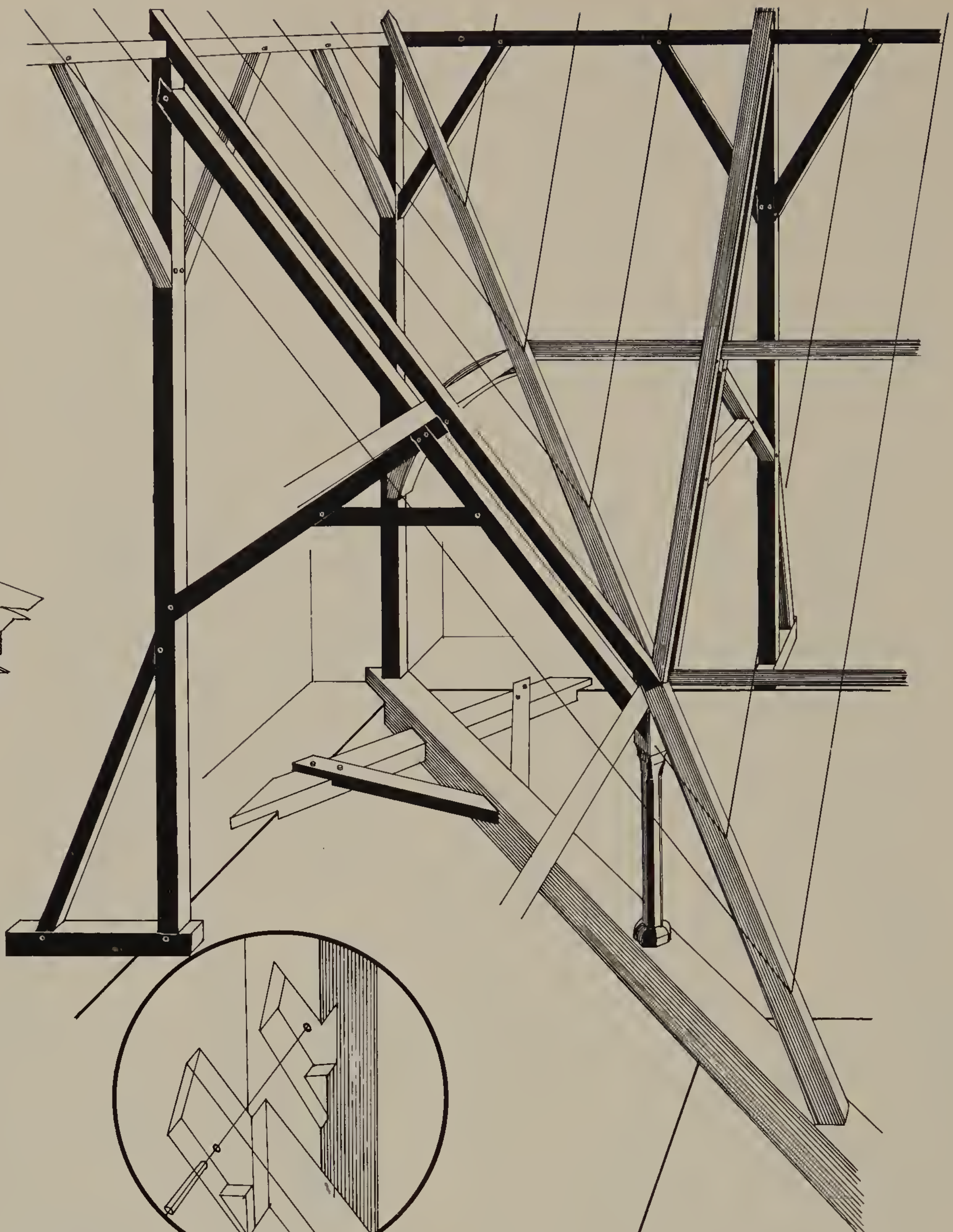


Fig. 137

parvise, is shown in Fig. 138. This is again valley-raftered, and the parvise roof is scissored. A selection of jointing devices and a vertical post are shown in Fig. 139, all from the northern triforium roof.

The southern nave triforium is very good, and of perhaps the opening of the eighteenth century; one frame of this is shown in Fig. 140.

The timber scaffolding which rises inside the tower incorporates the tread-wheel windlass, and ascends to the top of the spire; it is the original one set up as the spire itself was erected. This is not illustrated, but incorporates the important jointing device illustrated in Fig. 141: which is a splayed and tabled scarf with bridle-butted top member. Since

Fig. 138

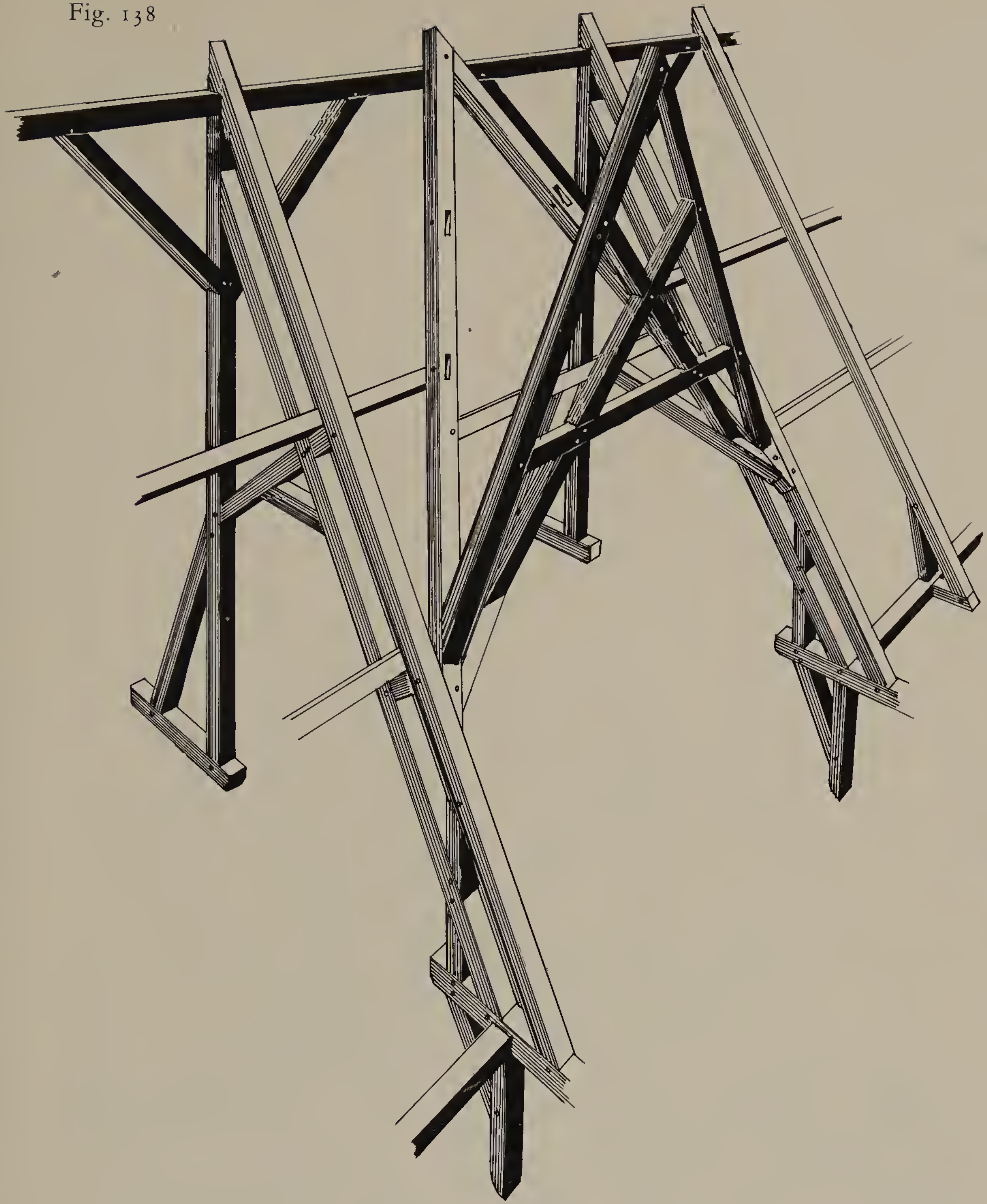
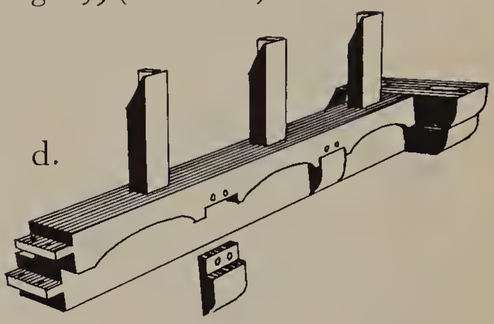
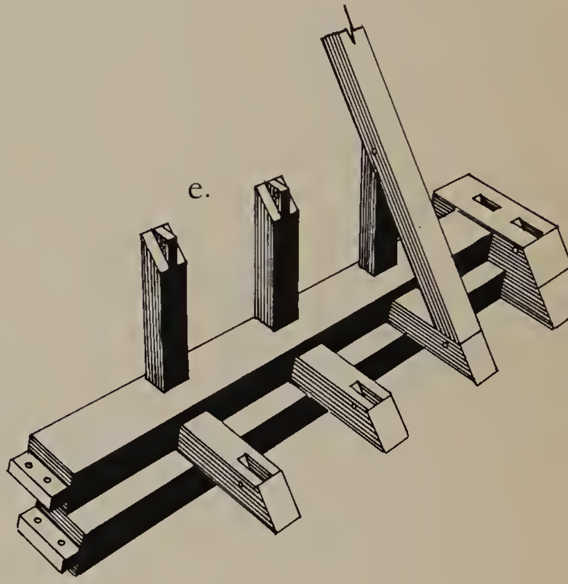


Fig. 139 (continued)



d. Front view of double wall-plates in triforium, ashlars'-plate with arcaded front and decorative pendants.



e. Rear view of same assembly showing in-canted ashlars and method of tenoning sole-pieces into return of double plates.

this joint occurs at the base of the spire a date soon after the commencement of that work is likely and before *c.* 1350 when a development of this principle is known to have reached Essex, at St. Clere's Hall, in St. Osyth's. It seems that the bridling of butts was applied to splayed scarfs for a period, and that the resulting joints gave rise to the edge-halved scarfs having bridled butts without any splaying, or diminution of their two members.

The west doors, one of which is shown in Fig. 142, are of interest since they are likely to be original to the west front, and therefore useful to compare with other similar doors—of less certain dates.

Fig. 140

Southwark Cathedral

Restored by G. Gwilt: 1822–35

Several roofs pertaining to the Gwilt restoration exist, and are of interest —none are illustrated. There are also many roof-bosses of oak, saved from a former medieval roof, now destroyed.

Southwell Minster

Restored by E. Christian: 1851

Only the north doors at Southwell are of interest, and medieval, being of the early fourteenth century; illustrated one page 98. The chapter-house roof is described on page 82.

Of the restoration by Christian, the two spires crowning the twin west towers are interesting; the base of one of these is shown in Fig. 143. Framed in pine, and heavily braced.

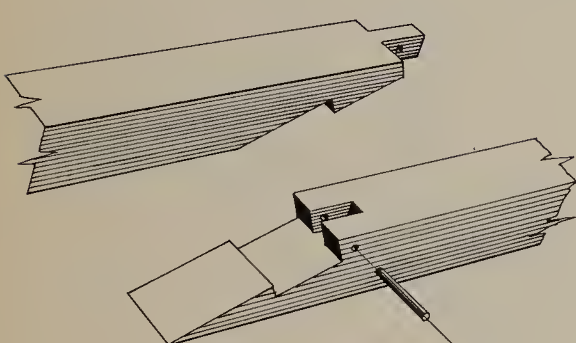
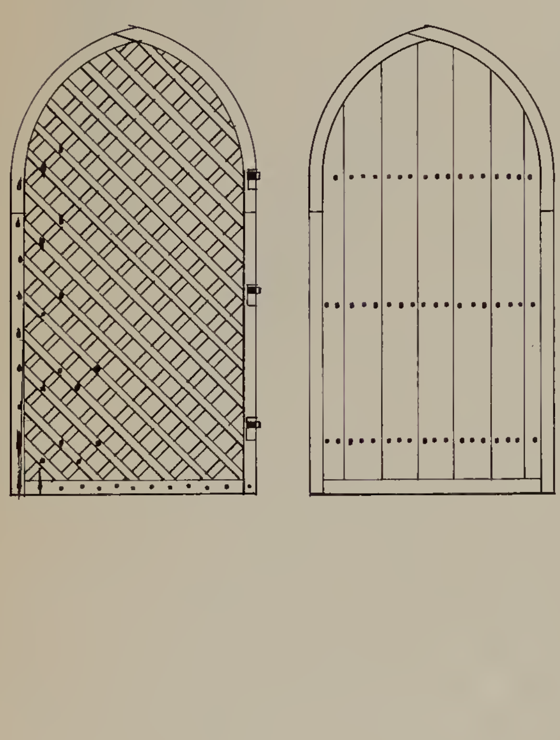


Fig. 141

Fig. 142



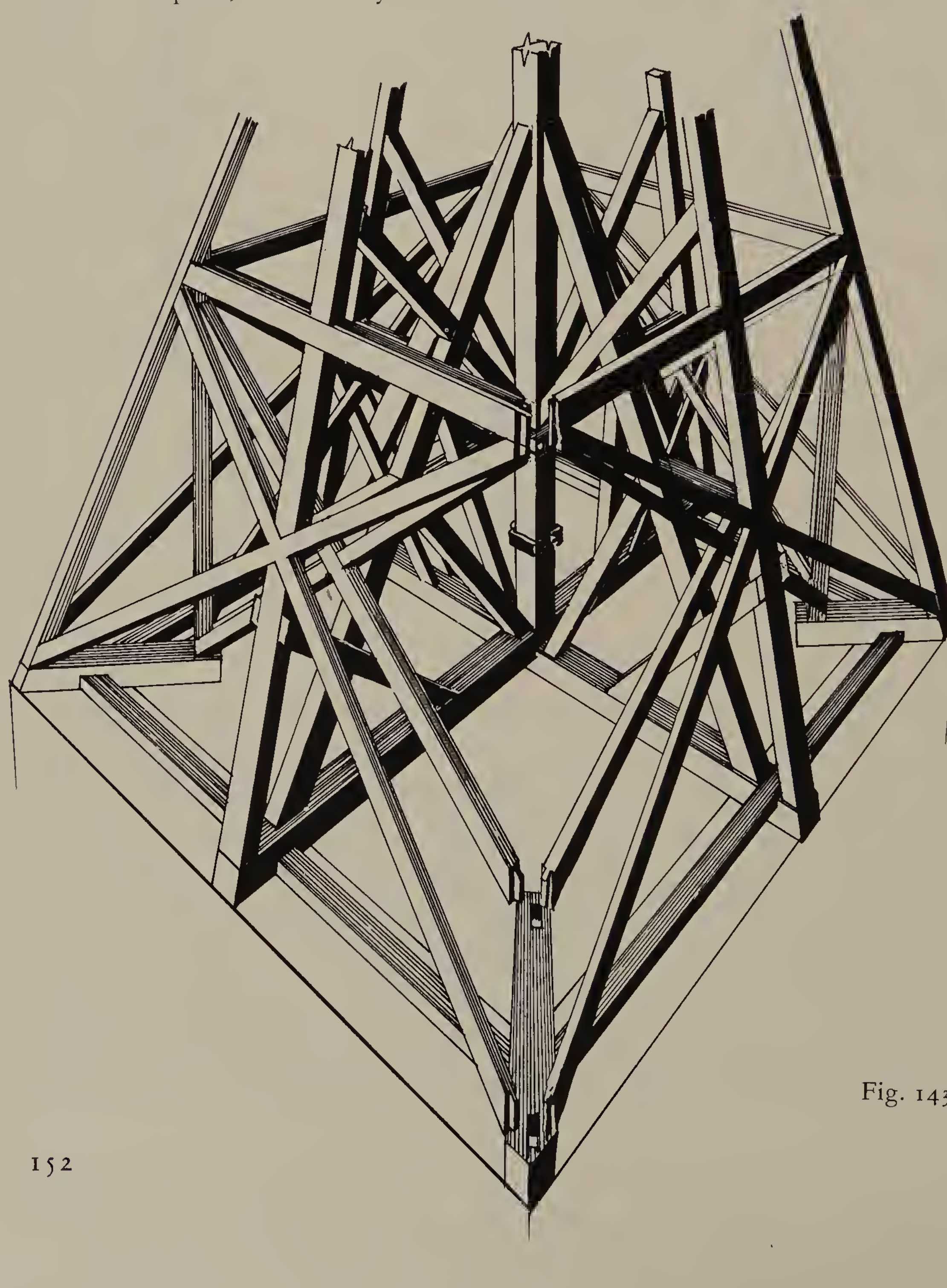


Fig. 143

Wells Cathedral

Relevant building-dates: *c.*1175–80—choir
*c.*1186+—transepts in progress
1209–13—Interdict (?"break")
1229—nave completed
1248—fall of *tholus* (?east)
1306—chapter house completed
1310–19—lady chapel completed
*c.*1310—eaves converted into parapet
1325+—eastward extension of presbytery

Two very important works of carpentry remain to be illustrated in respect of this cathedral: the roof of the lady chapel and the roof of the retro-choir. Both are high roofs. The lady chapel was finished by 1319, and the carpenter responsible was possibly John Strode. This roof is illustrated in Fig. 144. The plan of the building is an irregular octagon, which the carpenter tied with two beams from which short ties extend to what may be regarded as the "ends" of the irregular shape. The two tie-beams are set upon diagonally braced brackets and are fitted with a form of branching end provided to extend their tying action laterally. King-post trusses stand on each beam with a ridge-piece between them; supporting two "compassed" frames of the "wagon" type, these also possess high king-posts and doubled collars. Many principles that are represented by early examples of roofing in this present collection were

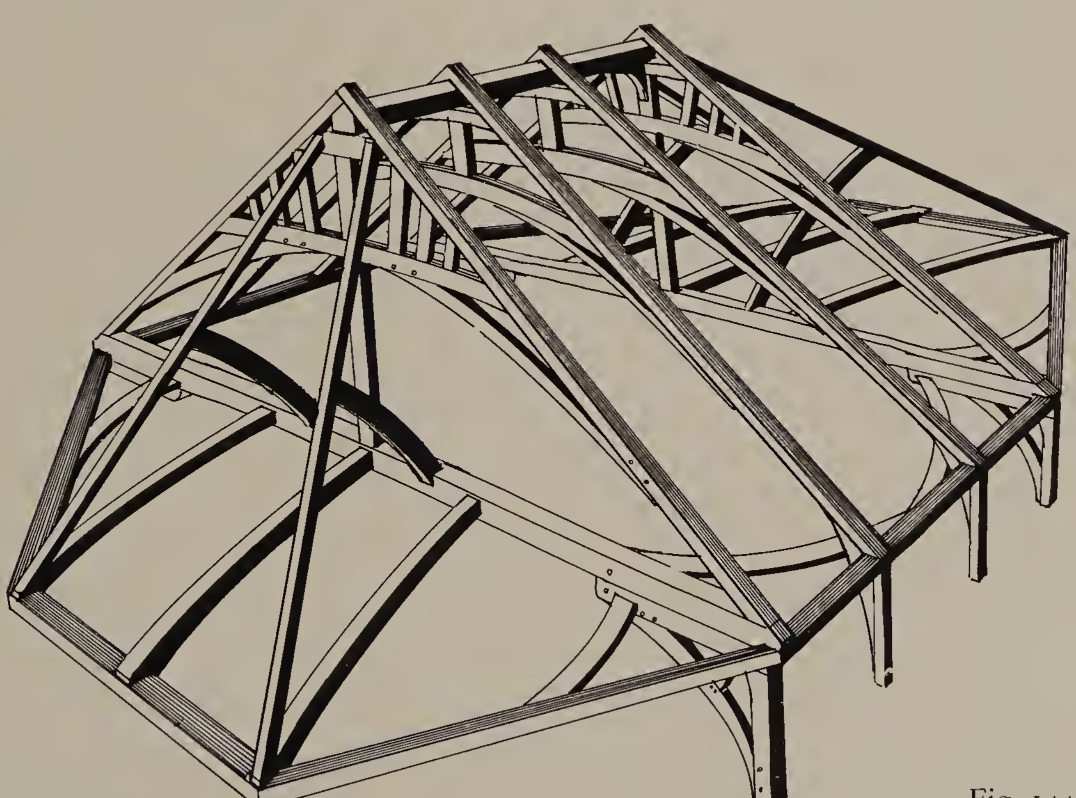
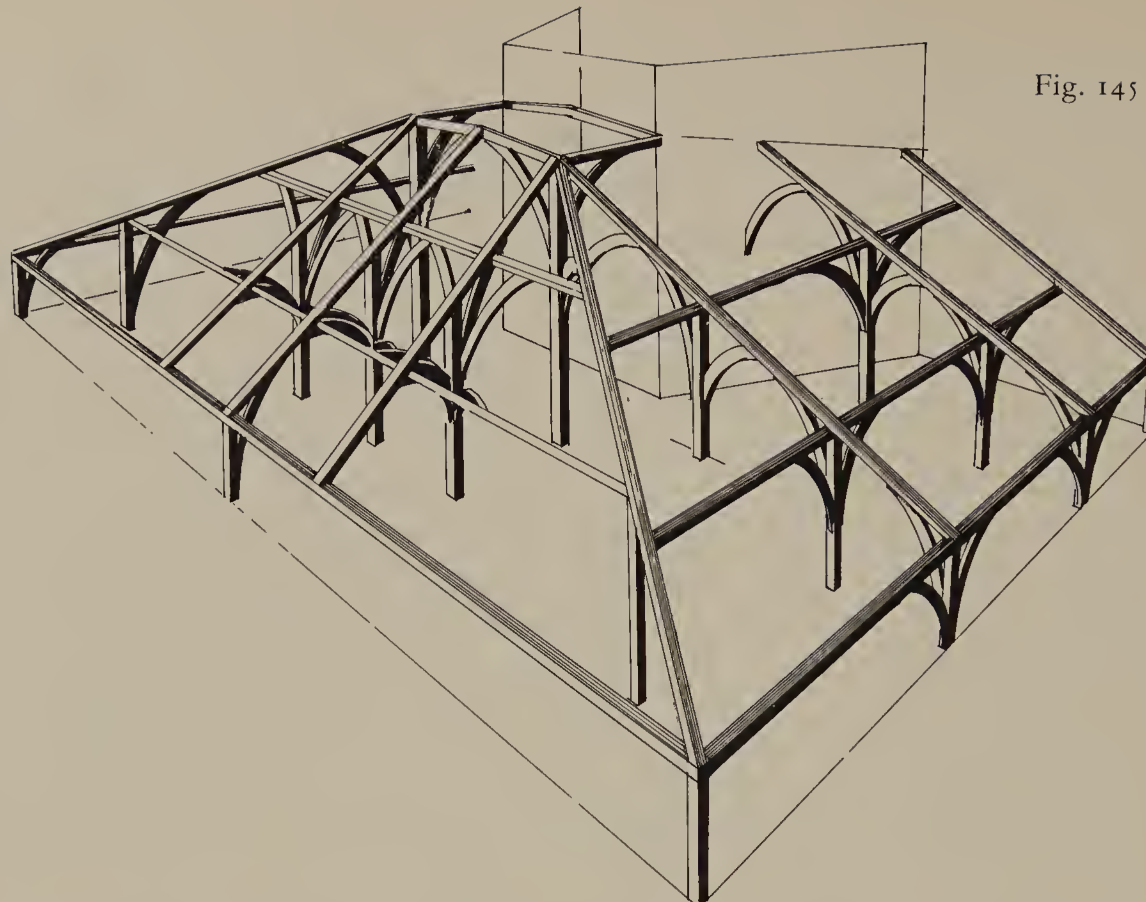


Fig. 144

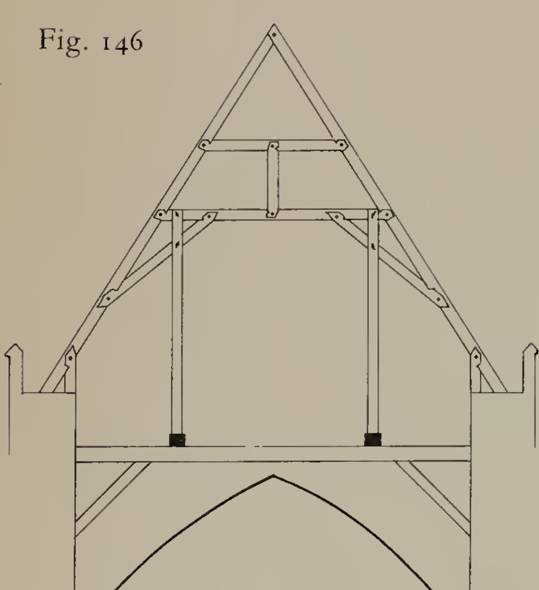
Fig. 145



utilised in this one roof, which is as a result an eclectic work. As such it indicates unequivocally that the structural traditions from which features were selected, such as low-pitched king-post and ridge-piece, arched to collar, and seven cants with compass-timbers, were all in use before the date of the work under discussion, which is early enough to affect the validity of other hypotheses. It is also important to note that this roof was pitched relatively obtusely at a cathedral where the majority of roofs were steeply pitched.

The retro-choir is very closely associated with the lady chapel so far as its dating is concerned, and *c.* 1329–45 is one possible ascription for it. This is a remarkable roof, which is illustrated in Fig. 145. It is curious in that, being essentially a hip-roof, it is pitched against a relatively flat-roofed and rectangular structure, around which numerous posts with well-accentuated jowls gather and concentrate its weight onto selected points on the complex vaulting. I have seen no other timber roof that incorporates curved bracing to such a prolific extent; there are in this example posts with as many as *six* curved braces from the same level.

Fig. 146



At the date when the parapet was substituted for the preceding eaves, the nave roof was supported during that operation by the method shown in the diagram constituting Fig. 146. Since the tie-beams were to be left in place and embedded in the masonry, they were given longitudinal plates to carry, from which posts—as shown in the figure—were forelock-bolted to both collars and "soulaces". It seems that thereafter

the feet of the couples were sawn to the predetermined line of the parapet (probably one bay at a time) and the masonry raised to that level. It was realised at the time that the stability previously given by the eaves triangulation had been destroyed, but instead of jointing the sole-pieces back at the higher level the queen-post type supports were left in position—and no failure has yet resulted from this. The latest of the Wells roofs is shown in Fig. 147, which is that over the vaults of the northern transept. This work may well date from 1661—when the sum of £227.63 was spent upon "timber and workmanship about the Church".[84] The bolts used for its construction have screw-threaded nuts and, if original, Wells would pre-date St. Paul's in their application to roof-framing. The structural design of the roof is most interesting in that it derives so clearly from the conversion of the nave roof previously shown, with the difference that its weight is transmitted directly to the crowns of the vaults. The curved ashlar-pieces are re-used, presumably from the preceding roof of this transept, and applied by bolting them to their rafters. Some of this timber appears to be larch, and the wall-plates are of oak, as are the re-used items of timber.

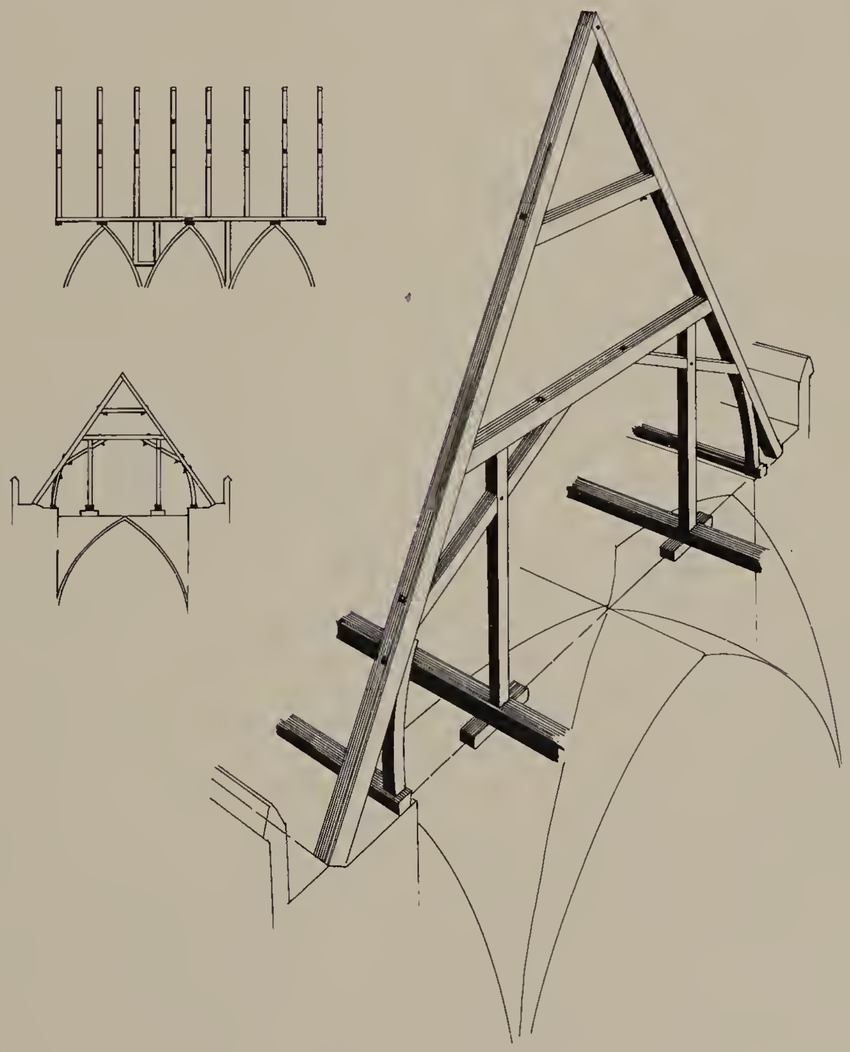
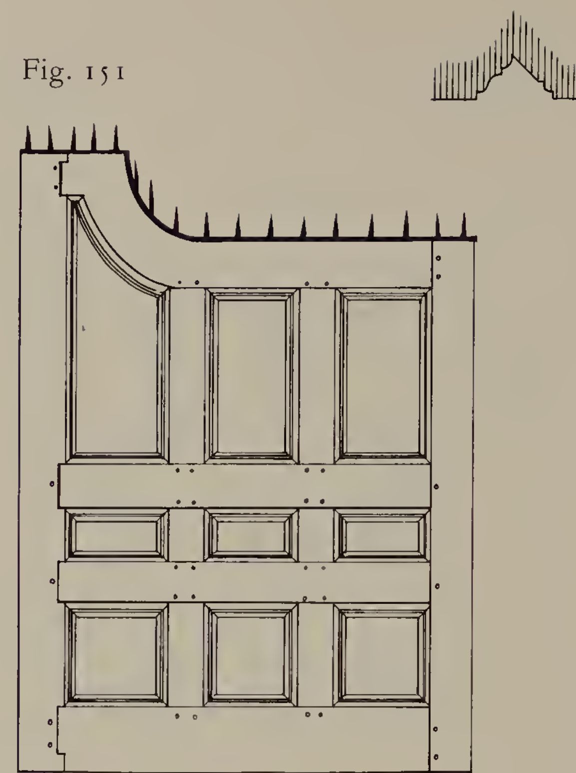


Fig. 147

Fig. 150

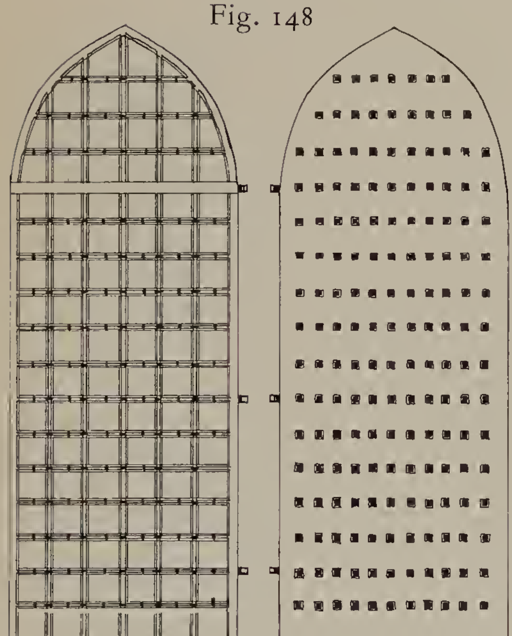
Fig. 149

Fig. 151



Original timber doors are so numerous at Wells that they will not all receive the attention they merit, and a selection is illustrated for the present purpose. An outer and an inner face of the central pair of west doors are shown in Fig. 148. There is no obvious reason why these doors should not date from the completion of that front between *c.*1230–60. Their clenches have squared heads which were carefully set in chiselled counter-sinkings as shown, and closed over roves that were still set across the grain of the ledges. The traceried door with segmentally arched head shown in Fig. 149 is that giving access to the chapter house from the Cathedral; only the decorated front-face is illustrated and its rear frame is of squarely disposed and chamfered ledges. This is dated to *c.*1305 and is assembled by spikes, of the type having four points beaten from the corners of their square heads—such as were used in the eastern apse roof at Westminster—in this way four points prevent the head from turning with regard to the surrounding wood. One of the pair of doors in the south aisle screen is shown in Fig. 150; these are believed to date from after 1364 and their central third-height tracery is pierced, while the more complex tracery running into the ogee heads is backed by thin planking, and blind. Finally, the wooden gates fitted across the entrance to the north porch, which are shown in Fig. 151; these are good fielded panels having both cyma and round mouldings planed onto their edges. These gates are, today, hung inside outward since those faces were thought to be in better condition. A section through a panel and a muntin is given at top right in the drawing.

Fig. 148



Winchester Cathedral

Relevant building-dates: *c.*1315–60—presbytery
1394–*c.*1450—nave
*c.*1520–32—presbytery, clerestory

Concerning the high roofs of Winchester I am assured[85] that no records concerning the building-dates exist, and the four examples not already alluded to will here be illustrated. What appears to be the least altered of the two apparently earliest designs is the high roof over the south transept, which is illustrated in Fig. 152. This is of five bays having seven couples in each bay—so far as my notes show no wall-plates have survived. The chase-tenon is the main joint used, and the design, in having bay-interval queen-posts with crown-pieces above that connect two collars over a seven-canted lower void, has affinities with both Salisbury and Lincoln, as well as with Wells and Exeter. A date for this could be very close to *c.*1300; but as previously stated the patination of timbers at Winchester seems to be the result of a benign atmosphere, and does not help with a date-ascription.

The high roof of the nave is, or was initially, the same as that of the transept just described, and is illustrated in Fig. 153, which shows its present condition; with side-purlins intruded and mounted on queen-posts having straight bracing to the purlins. The evidence for their being intrusions consists in the fact of these straight braces being seriously cut in order that they might avoid the earlier "soulaces". In addi-

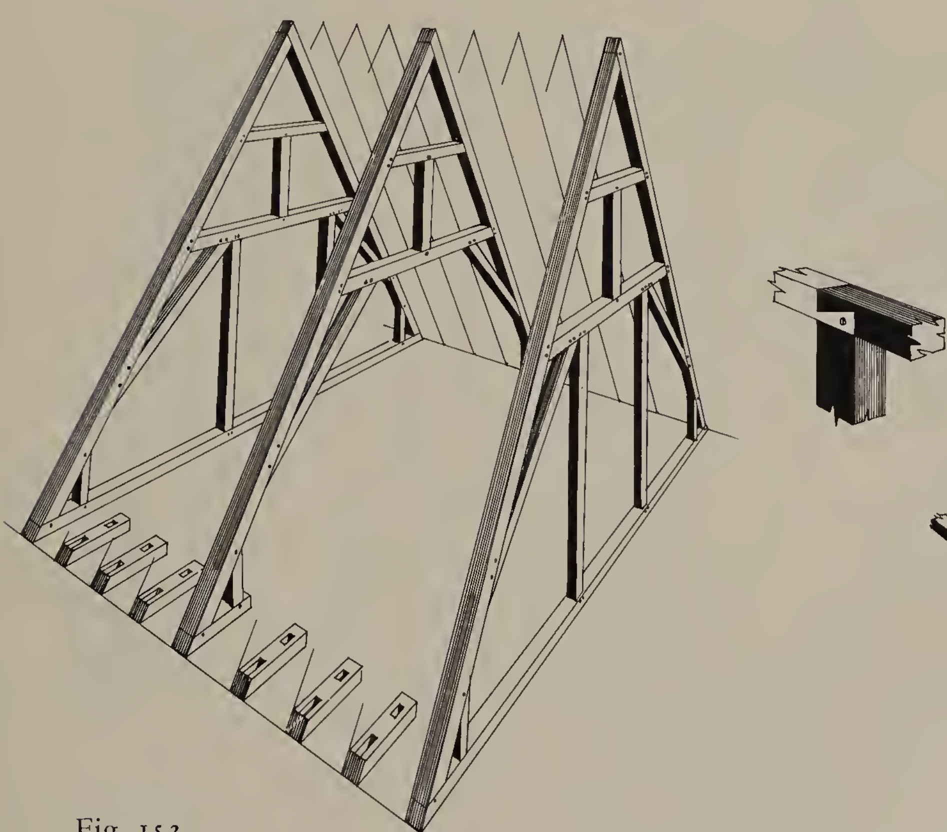


Fig. 152

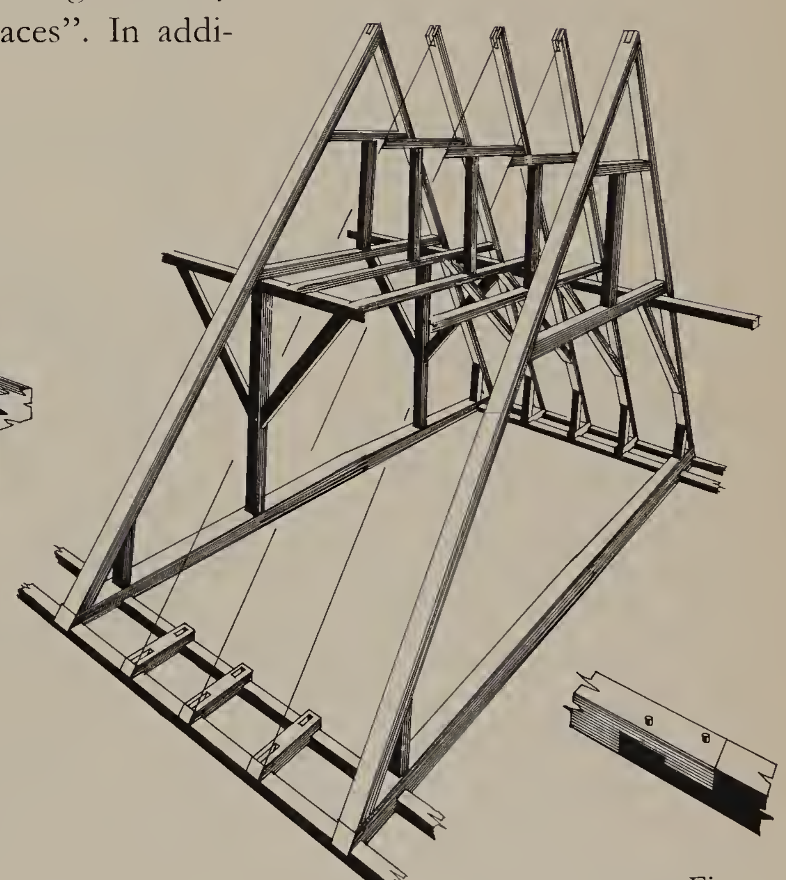


Fig. 153

tion to this fact, the purlins are scarfed as shown at the upper left of the drawing, in clear contrast to the inner wall-plates which are scarfed (where checked) in the manner illustrated at lower right of the same drawing. This last scarf is, apart from the present context, quite peculiar to the roofs that have survived from the first build of Salisbury Cathedral; and may be a strong indication of a date in close succession. The date cited for the nave could well apply to the intrusion of the side-purlins.

The high roof over the north transept is illustrated in Fig. 155, which also shows the forelock-bolted assembly of the paired queen-posts; these trap the scissored or raking braces used in alternate frames, which is clear evidence for the design taking account of a vault beneath—since the wall-posted frames occupy the "pockets" and the alternates the ridges of the vault. This roof relates only to that over the presbytery, and a relatively close date would seem probable; as would the same carpenter for both works. The high roof of the nave was either re-roofed or extended westward at some date, since five king-post trusses of the type

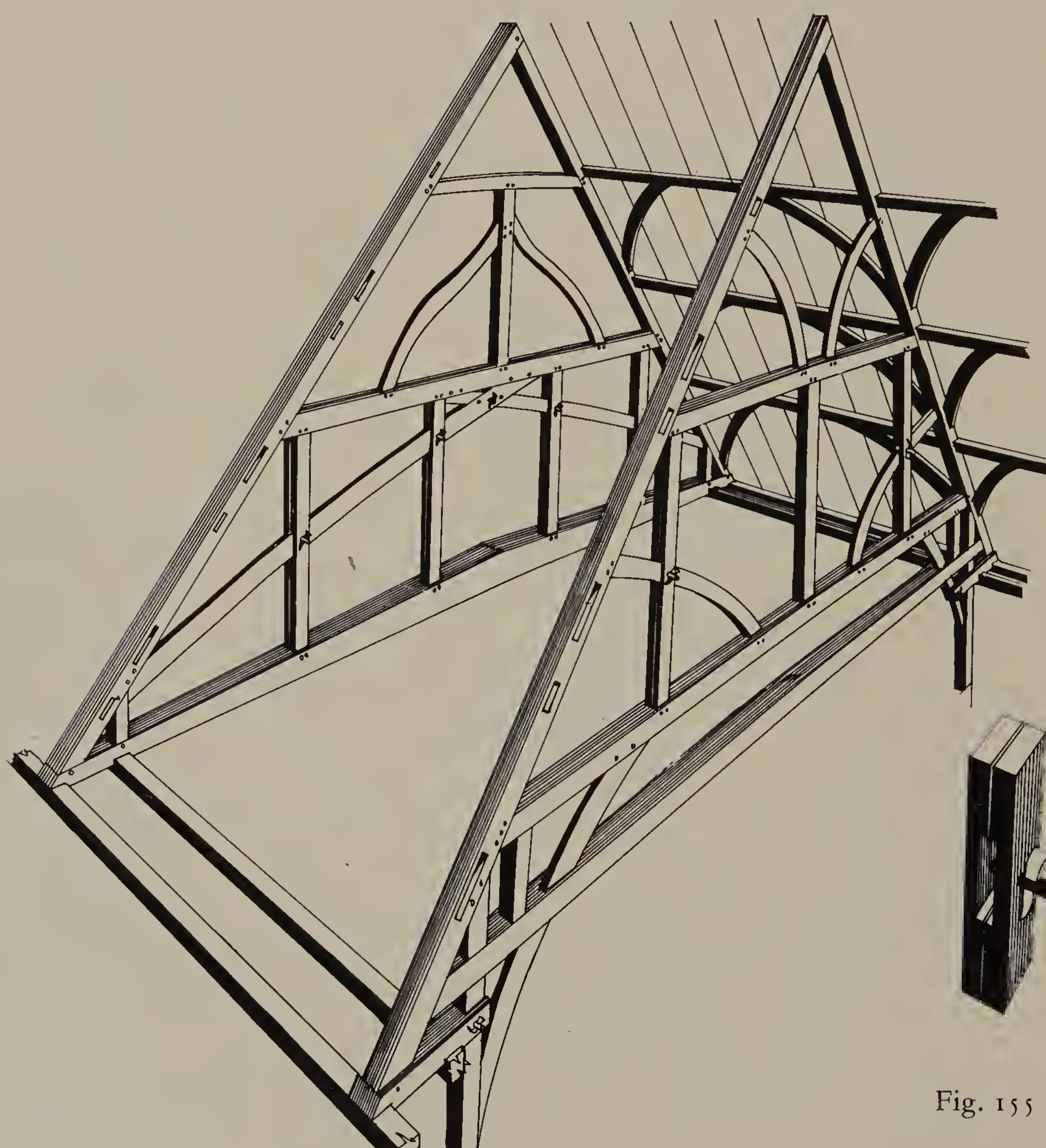


Fig. 155

shown in Fig. 154 were there used and define bays having seven common rafters each, with ashlar-pieced feet. The king-posts have strap-irons that are affixed with forelock-bolts as shown at the left of the illustration—I am assured[86] that documentary evidence exists that dates this part of the roof to 1699.

An interesting lean-to roof exists over the triforium aisle of the south transept, and of this one bay is shown in Fig. 156. This is entirely of oak that is straight and clear, but affords no structural detail that can materially assist with a dating for the work. Similarly difficult timber-frames exist in the central tower, and a wall-piece from the belfry-floor is shown in Fig. 157. The tower itself is dated[87] to *c.*1108–20, and the stone corbels, which have finely carved human faces as chamfer-stops (shown in the drawing), may be of that date; but the timbers must be later in view of the jointing by chase-tenons.

The roof over the northern nave triforium has a flattish pitch and upright struts to its highest purlins, while the lower purlins are trapped

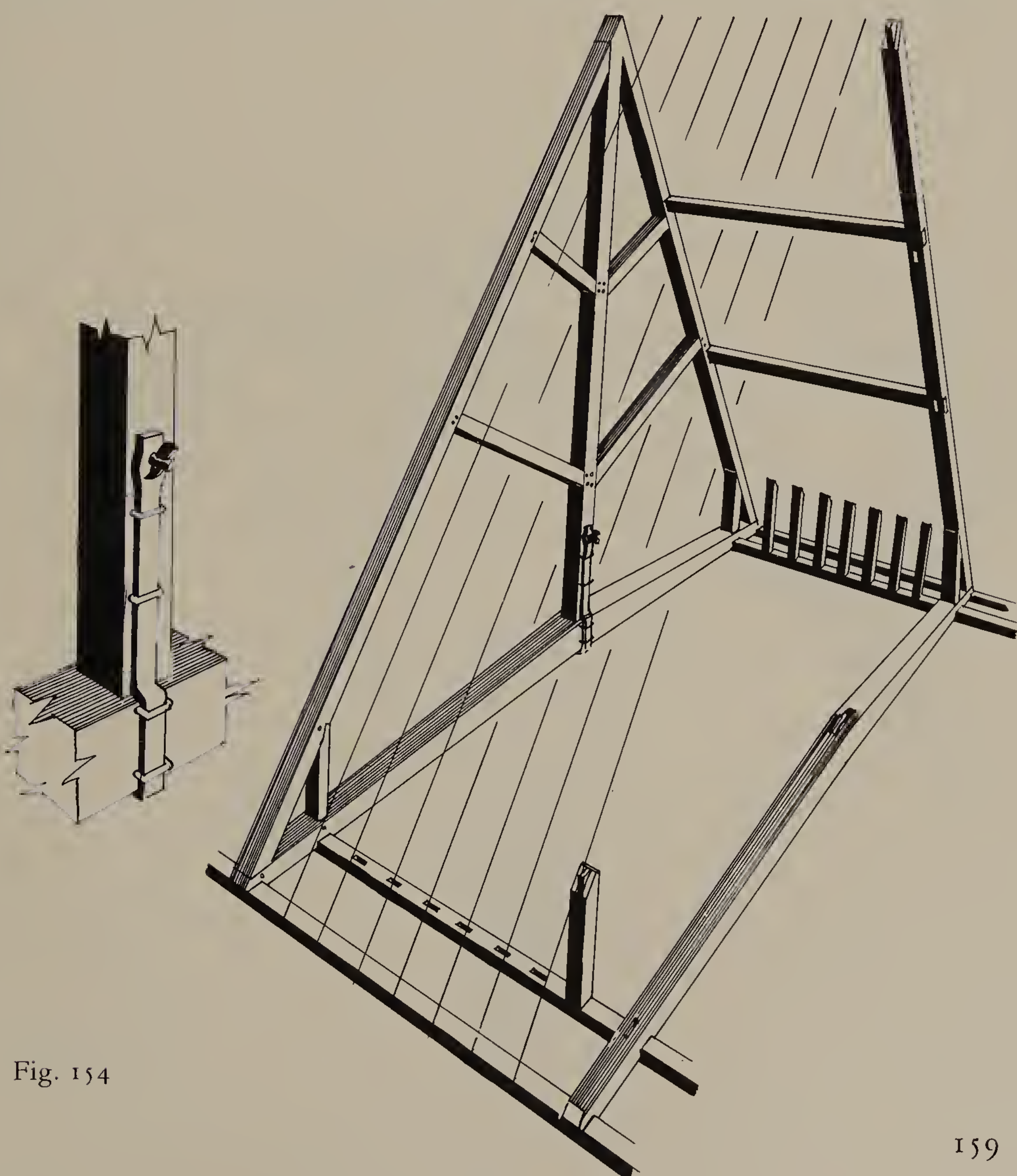


Fig. 154

Fig. 156

Fig. 157

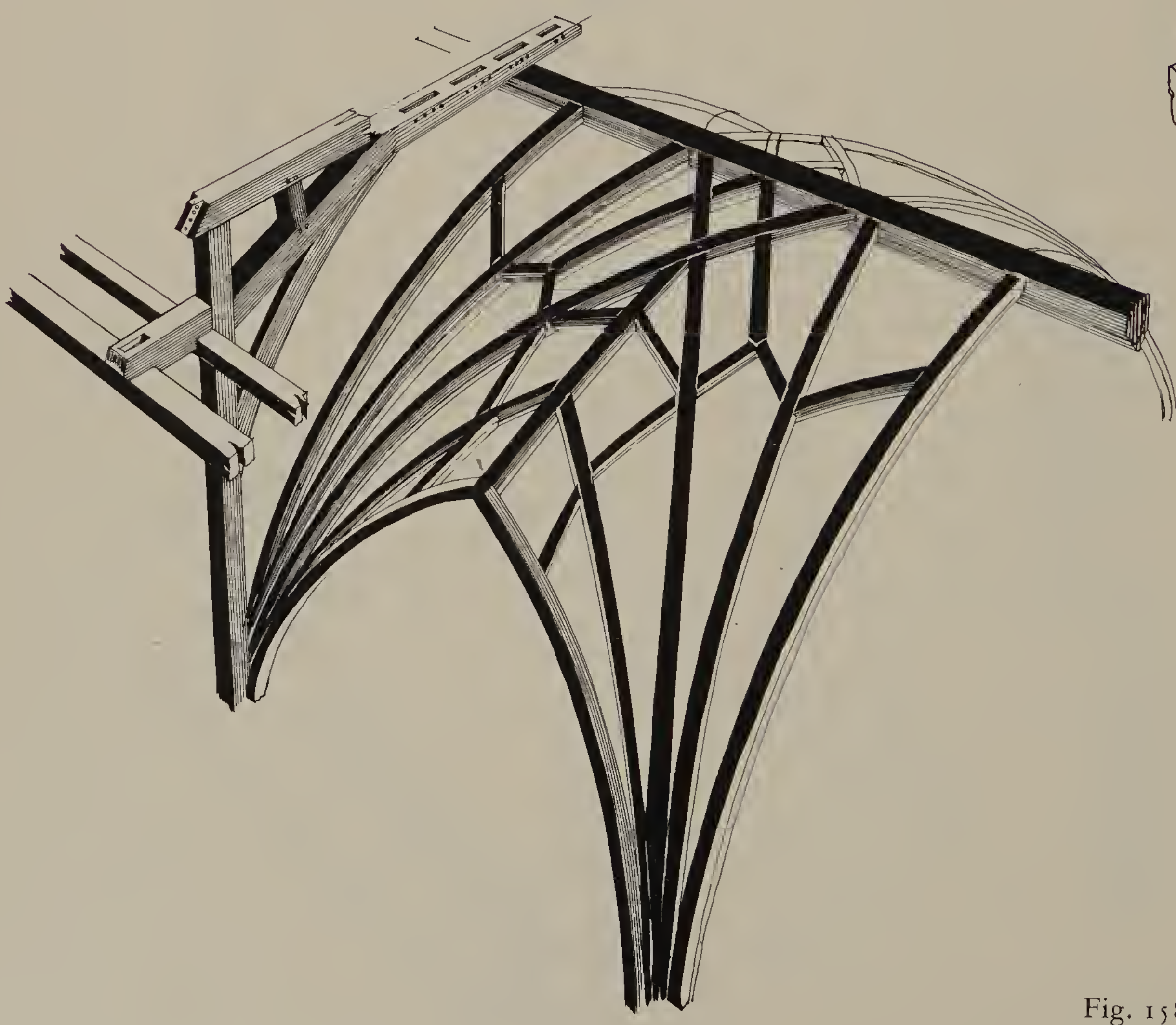


Fig. 158

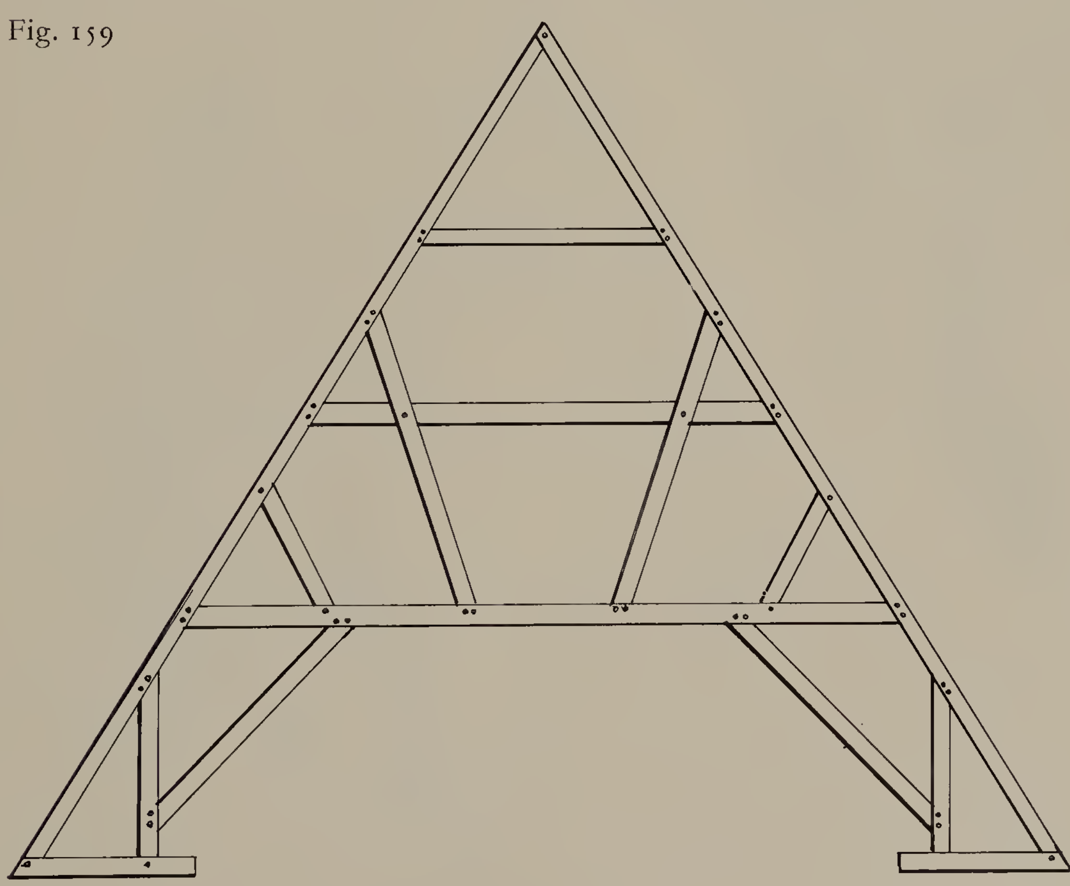
between the ties and the principal rafters. The wall-plates to this example have short halved and bridle-butted scarfs making a sixteenth-century date probable for the work. One fine planked and cross-ledged door exists in the south transept, which is not illustrated; this has its head worked to a four-centred arch and is decorated with strap-rides that branch into naturalistic forms, stylistically. Early English door-ironwork.

The most interesting fragment of unknown purpose is a timber Norman capital on a short circular timber column that stands quite isolated in the centre of the south transept gable, at triforium height; this is evidently fixed to the masonry of the wall, and has a stone corbel beneath it. This item is quite inaccessible and cannot be properly examined. A diagrammatic view of the timber vault-pattern, in the presbytery, is given as Fig. 158.

Worcester Cathedral

The high roofs at Worcester are the result of a re-roofing in which previous roof-timbers were re-cut and used again, since open notched lap-joints exist on them in sufficient numbers to render a reconstruction of the earlier roof feasible. Three frames from the west end of the nave are as illustrated in Fig. 159, which is a type of roof affording few comparisons in this country. These frames are stilted, as shown, but the existing

Fig. 159



vaults do not have their crowns at such a height as justifies this—it may be possible that the eaves masonry has been raised at some time in relation to the vaults. A considerable number of bays following these, after a clumsily contrived junction with a double frame, are of the type shown in Fig. 160. These are actually of more slender timber than the diagram shows, almost all of which has been used previously; in these cases also the frames were designed to clear the vault-crown which does not, today, rise a height that justifies the framing. One bay is fitted with common collars and some of the common rafters are scarfed together as shown in the illustration, with the type of joint most used during the early fourteenth century; all these timbers are creosoted and it is not possible to assess their age from patination.

The high roofs of the choir and eastern transepts are roofed in oak with trusses of the type shown in Fig. 161. These are unusual in that they are forcibly braced into square at tie-beam level by means of diagonal timbers with wedged ends, shown at the left of the drawing. The king-posts are equally interesting in that some were originally steadied longitudinally a few feet above the tie-beams. The roofs of the transepts are well framed together with that of the choir at the crossing. All the ironwork is forelocked-bolted, and a date during the seventeenth century is probable.

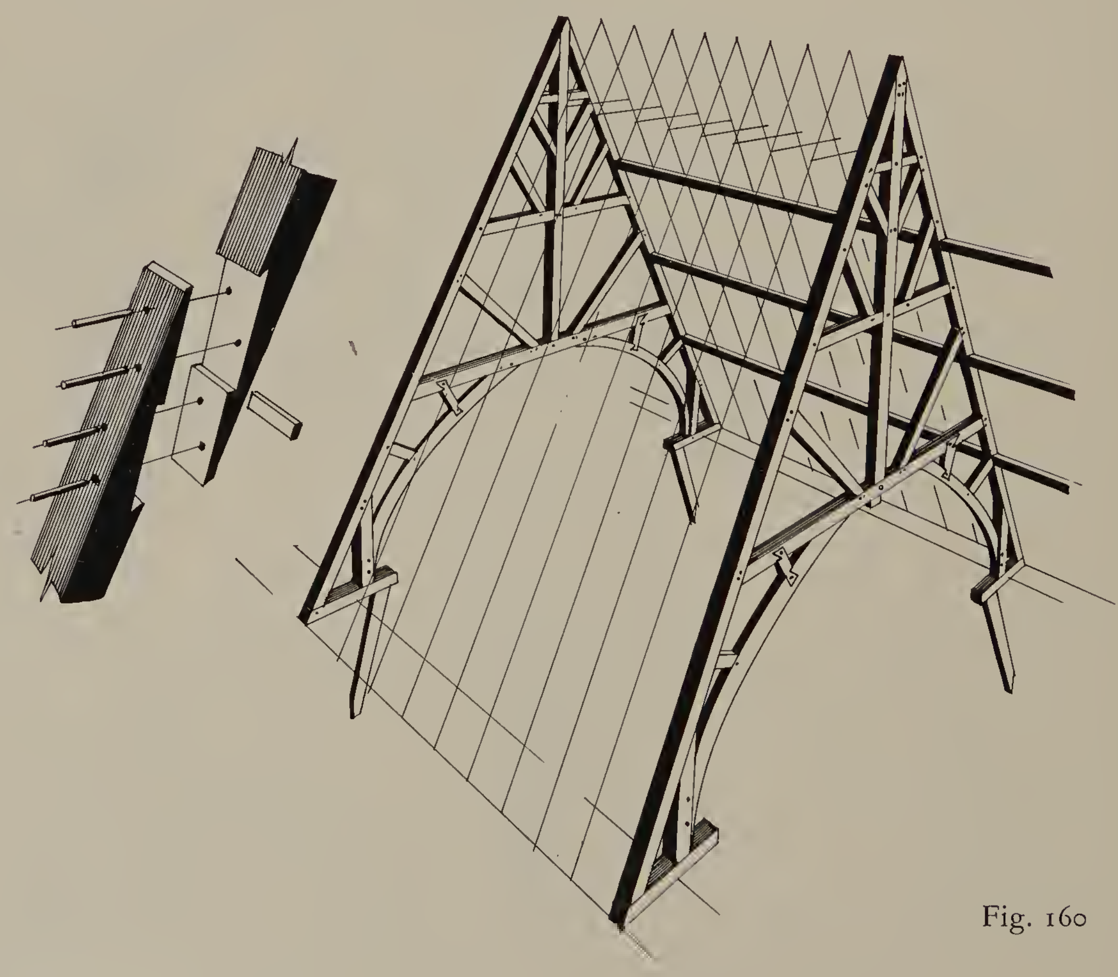


Fig. 160

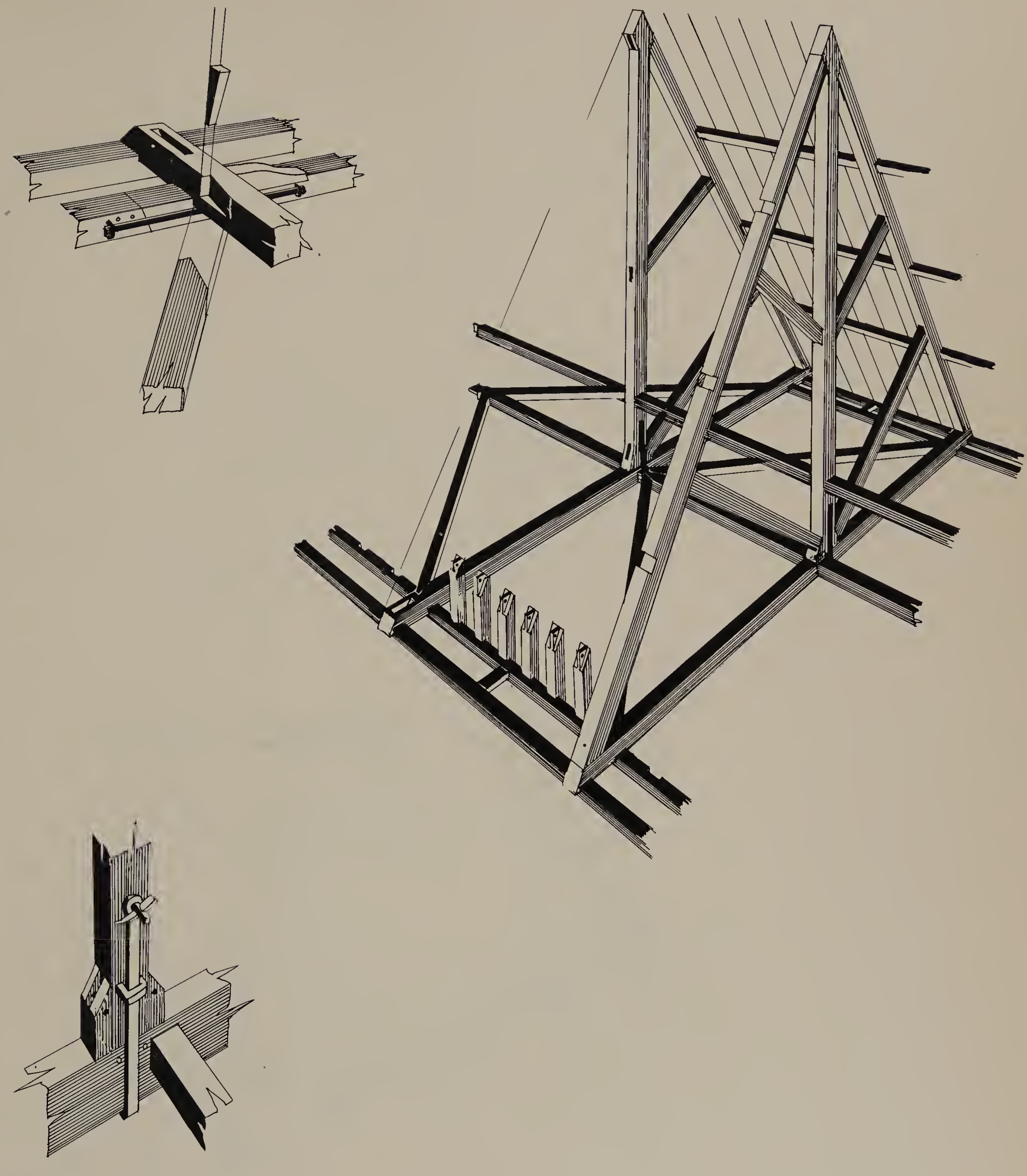


Fig. 161

The doors existing at the main arch under the Edgar Tower are of interest, although not illustrated. These fit the single-centred arch in Norman style, are tenon-jointed apparently and cross-ledged upon both faces—in the manner used at Selby Abbey for the west doors.

York Minster

Relevant building-dates: 1225–34—north transept
c.1230–41—south transept
c.1286–96—chapter house
1291–1345—nave
1354–70—nave vault, timber, by Philip Lincoln

One timber high roof at York that has not been described is that over the nave, by Sir Robert Smirke, and occasioned by the restoration of 1840–4. This is illustrated in Fig. 162 and is of mixed oak and pine. All bolts are screw-threaded and it has twelve common purlins in each slope. An interesting development in this case is the setting of the lowest purlins directly on top of the ashlar-pieces as shown. The surviving upper halves of the south-transept south doors are excellent but have been reframed on their rear faces. These are illustrated in Fig. 163.

Fig. 162

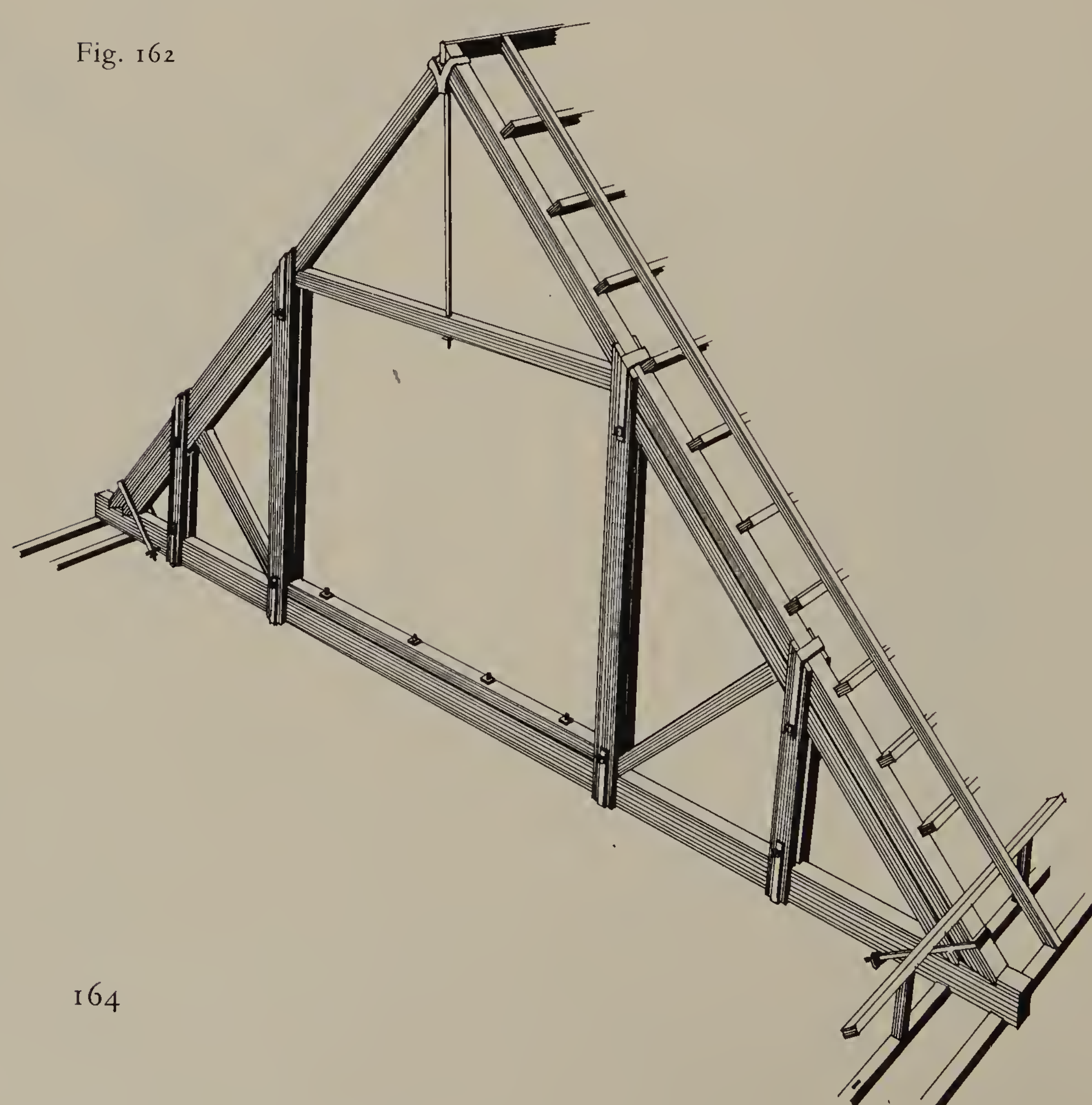
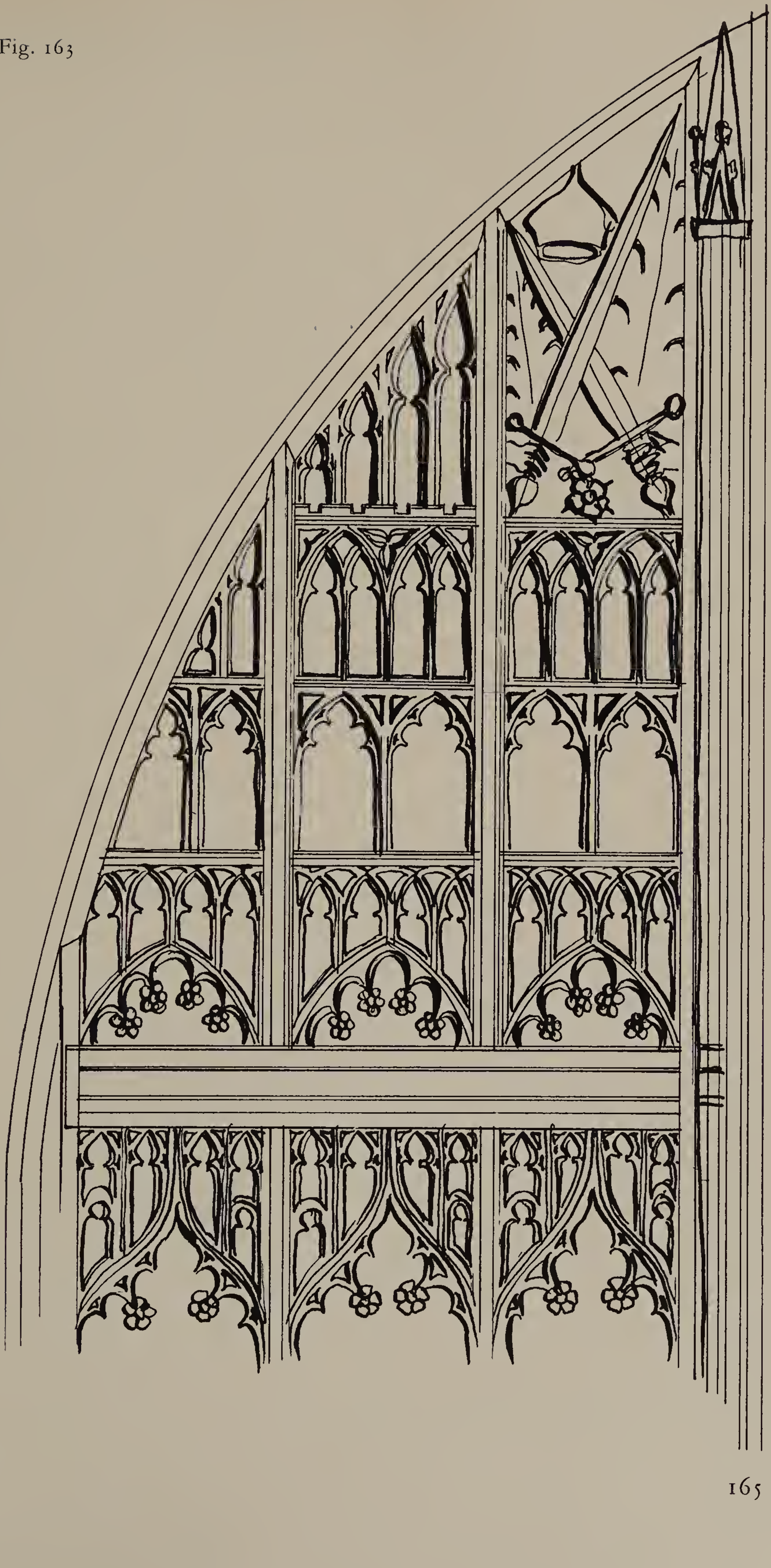


Fig. 163



GLOSSARY

ABUTMENT *Abut*, O. Fr. *Abuter*, to touch at the end (*á*, to, *bout*, end). Any point in timber jointing where one timber's end touches another constitutes an abutment. By this token "a butt-joint" is one where two (or more) ends meet—no integration is implied.

ARCATURE The curvature of an arch.

ARCH BRACE A term that has come to mean specifically a brace of curved or arched form, usually beneath a tie-beam.

ARRIS The line or edge at which two surfaces forming an exterior angle meet each other.

ARRIS-TRENCHED Trenched (q.v.) so that the trench is cut obliquely across the arris and affects both of the adjacent surfaces—the face and the edge.

ASHLAR-PIECE Short timbers forming the vertical side of a triangulated rafter's foot. In stone-walled buildings these continue the inner surface of the walls up to the underside of the inclined roof. Their actual function was to complete the triangle of the rafter's foot, thereby increasing that timber's bearing.

BAREFACED LAP-DOVETAILS See Figs. 5 and 12, wherein the top ends of the scissor-braces are so jointed. In carpentry this term is specific and is used only of a joint that continues one edge or face of the timber concerned. How it came to have this meaning is difficult to determine.

BIRD'S-MOUTHED Said of any part of a joint resembling the open beak of a bird, this is normally a V-shaped abutment, fitting over an arris. Sometimes used for rafters' feet that meet wall-plate arrises.

BOX-TIES Any carpentered component is called "boxed" if possessed of four sides with an open centre. There are thus box-ties, box-collars (normally encircling posts) and box-tenons, which are arranged on end-view in the form of a square. A box-tie would encircle the members to be tied together.

BRIDLED The name of a category of joints deriving from the harness item, which is the bit and reins used to control a horse. Normally these joints have a part approximating to the bit, which fits into a "mouth" slot, cavity or open-mouthed mortise designed to receive it. Frequently used to join rafter-couples at the apex.

BUTMENT-CHEEKS These are specifically the two areas of a timber that are left on either side of a mortise.

CAMBER BEAM A beam forming the basis of a simple roof, to which either purlins or rafters are applied, the whole being clad to make it weatherproof. Such very simple roofs were much advocated by the Tudors. So named because the beams traditionally had an upward curvature, in order that they should not seem to sag.

CANT "An oblique, inclined or slanting face 1840" *(OED)*. These are the short inclined planes that form the archivolt (see soffit) of a "trussed-rafter" roof.

CEILED Fitting with a ceiling.

CHASE-TENON A form of tenon that is capable of entering its mortise in two ways since the mortise is elongated and has one end sloping and the other square.

CLASPING SCISSOR-BRACES Scissor-braces (q.v.) applied to both sides of the rafters. Similar clasping queen-posts (q.v.) are shown in Fig. 154.

CLENCHES Spikes or nails that have their pointed ends riveted or bent and re-driven.

COLLAR-TIES Collars that serve as tie-beams placed unusually high between the rafters. Having unwithdrawable end-joints, they prevent the rafters spreading at their feet.

COMMON PURLIN Purlins that form the majority of timbers in the pitch-plane, or a single slope, of a roof.

COMMON RAFTERS Rafters to which the covering is attached and which in the oldest practice form the majority of timbers in the roof's slope. *See* principal rafter.

COMPASS-TIMBER Shipwrights' term describing curving or arched timber, but specifically grown to that shape, and not applied to curves that are cut from naturally straight wood. Thus compass-timber was provided mainly from the limbs of pedunculate oaks, and large pieces were derived from specially trained trees that were forcibly bent and then left to grow in the desired curve.

COUNTER-REBATE To rebate in two, opposite, directions—as shown in Fig. 85.

CROWN-POST A vertical member in a roof, rising from the centre of a tie-beam as high as to the collars—normally mounting at its top a purlin.

CROWN-PIECE Diminutive of crown-post; that is, of shorter length—as in Fig. 14. Crown-posts and -pieces do not reach above the collars, whereas king-posts or -pieces actually pass between the rafters at the apexes.

CUSPED Having apexes, or points. In Gothic these are formed by the juxtaposed segments of the circle.

CYMA The moulding of reversed curvature, essentially the ogee.

DIMINISHED HAUNCH See Figs. 33 at *B* and 34, wherein these are shown: they are sloping shoulders cut on one side of tenons, designed to increase the shearing strength of the tenons.

DURNS The timbers having curved ends that were used to form arcuated door-openings. Frequently one such was sawn into two producing a "pair of durns".

EDGE-HALVED, BRIDLE-BUTTED (SCARF) See Fig. 31 at top left.

EDGE-HALVED TABLED SCARF WITH SQUARE VERTICAL ABUTMENTS See Fig. 17 at lower right.

FULLERED Fullers are round-nosed, long-handled "punches" used by blacksmiths in order to reduce the thickness—and thereby extend the length—of the work-piece of iron. This is a forging method older than the "rolling-mill" used today for the same purpose.

HARR The timber forming one edge of a door, from which it is hung or hinged; opposite to its "head".

HIP-RAFTER Rafter pitched so as to bisect an angle existing on plan in order to produce a semi-pyramidal end to a roof; the alternative to a vertical gable-end.

HOUSED SOFFIT-SHOULDERS Said of the mortise and tenon when the lower of

its shoulders is housed within the lower butment-cheek of the mortise. This was a device used to strengthen the end-joints of floor-joists between *c.* 1480 and *c.* 1520, in which capacity it preceded the diminished haunch.

HOUSING Socket cut to accommodate the end of a timber, which end is not normally reduced in section. It does not constitute any kind of mortise.

JOWELLED The end of a timber that is expanded in order to provide maximum joint-strength, where tenoned. This gives broader shoulders—better able to resist movement.

KING-PIECE A diminutive of the king-post, not set on the tie-beam, but at some higher point such as a collar.

KING-POST A central, vertical timber in a roof-truss; this intersects the rafters at their apex and tenons into the tie-beam at its base. Unlike crown-posts, which terminate at the height of the collars. *See* crown-posts.

LANCET A tall and narrow window having a "sharply" arched head, or top. Characteristic of the Early English.

LAP-DOVETAILS The form of the dovetail joint that does not fully penetrate, which is the through-dovetail. A barefaced lap-dovetail is shown in Fig. 9 at left. It can also be "full" and have two shoulders. So named from its resemblance to the dove's tail's shape.

MASONS'-MITRES The semblance of a mitre, which is a bisected angular abutment, produced by stone-masons; in which the bisection of the angle is illusory, and forms a decoration.

MIDSTREY This is an ancient term, which is still in vernacular use, for the "porch"-like roof extending like a transept over the great doors of barns. It is in line with the threshing-floor, and the doors gave light to the threshers, while the roof gave dry cover for wagons not unloaded.

MUNTINS Derived from "mountants"—the vertical members of a series of panels, crossing the rails which are horizontal.

NOTCHED LAP A category of joint which *seems* to have been imported from France via Normandy. A lap-joint is effected by one of the timbers overlapping the other, and this is refined by housing the overlapping part in a socket of identical shape. When a notch or V-shaped indentation is cut from the lap and also left solid on the socket's edge the lap is rendered unwithdrawable in all but one direction. Four examples are shown in Fig. 3.

PLATE-HOOKS Worked stones set into a wall-surface so that a part projects. In this a trench is cut to accommodate a plate or the head-timber of a lean-to roof.

PLATE-YOKED Said of a pair of rafters, or blades, that are united at their apex by a third timber component—a plate-yoke—into which both are tenoned. Shown in Fig. 25.

PRINCIPAL RAFTER A rafter normally mounting side-purlins and of heavier section and greater strength than the majority. Their outer surfaces may be in the same plane as the common rafters or beneath the purlins.

PURLINS Timbers in a roof which join its successive frames or trusses together. They are either set in the slopes, when called side-purlins, or centrally, when called collar-purlins. They may have their faces set level or in-pitch, depending upon the roof-type involved.

QUEEN-POST Vertical timber in a roof-frame or truss which supports a side-

purlin or a collar and stands on the tie-beam. Invariably found in pairs, one under each purlin.

RAKING-STRUT A roof-frame component that rises obliquely from a king-post or tie-beam or queen-post and supports the rafter of that frame, which it meets at 90°.

RETURN In brickwork, masonry or carpentry this term defines an angle.

RIDGE-PIECE Timber actually forming the apex of some roofs, into which all rafters tenon. Definable also as a ridge-purlin.

ROVE To draw through an eye or aperture. As clenches or rivets through a pierced metal plate before beating their ends out to prevent their returning through the eye.

SALTIRE A diagonal cross, also called St. Andrew's Cross.

SCARF From the Norwegian *skarv*, "piece added to lengthen". In carpentry this denotes the formation, by jointing, of an apparently continuous length from two separate short lengths. The methods used have been many and varied, and are a valuable guide to dating.

SCISSOR-BRACES Braces crossing in a saltire, specifically in a roof-frame.

SECONDARY RAFTER A rafter set parallel to, and at a distance from, a principal rafter in the same vertical plane.

SHUTS These are the edges of doors, opposite to the hinges; or shutting-edges.

SOFFIT The under side or surface. Also archivolt.

SOLE-PIECE OR -PLATE Short timbers forming the base of the triangle at a rafter's foot. Sole-piece at the foot of a common rafter; and sole-plate at the foot of a principal rafter.

SOULACE Short timbers triangulating the conjunction of rafters and collars, they are beneath the collars. This is a medieval term, which should be used since it is absolutely specific. The fashion for calling these surlaces "collar-braces" leads to confusion since that term has many interpretations. They can tie, or strain, according to method of joint and design of roof. For examples of the use of the term see L. Salzman, *Building in England* (Oxford University Press, 1952).

SPANDREL The space between the curve of an arch and its enclosing return, or angle.

SPLAYED-TABLED (SCARF) See Fig. 16, where this joint is shown at top left on the end of the collar-purlin.

SPUR-TIES Short ties, modified tie-beams.

STOP-CHAMFER A chamfer which is a bevelled narrow surface created by removing the arris of a timber, which ends at points where the arris is preserved—normally for the purpose of cutting a joint.

STRAINING-COLLAR A collar between a pair of rafters whose function is to prevent their closing together. This function is determined by the form of joint used at their ends.

THOLUS From the Greek *tholus*, "a dome". It is uncertain what was meant by this term at Wells in 1248; but *not* actually a dome.

TIE-BEAM A transverse timber in a roof designed to tie the rafters' feet together, i.e. to prevent their tendency to move outward or apart.

TRAIT-DE-JUPITER Name anciently given to the splayed and tabled scarf-joint, since it resembles the zig-zag course of lightning.

TRENCH In carpentry this is the groove created by removing wood from between two saw-cuts.

TUSK-TENONS A much-misused term. Old English *tusc*, "a tooth especially developed so as to project beyond the mouth" *(OED)*. This is a tenon which completely penetrates the mortised timber and is normally transfixed on its farther side to prevent its returning. Since 1679 this has been taken to mean a tenon with diminished haunch since such tenons were frequently "tusked".

VALLEY-RAFTER A rafter set along the line of re-entrant intersection of two inclined planes of roofing. The antithesis of a hip-rafter (q.v.).

VOID Empty, unoccupied—an empty space, or cavity. In architectural elevations doors and windows are "voids" while the walls are appropriately "solids".

WALL-PLATE Timber laid on, or set in, the upper course of a wall on which roof-framing is mounted.

WIND-BRACE A brace in either a wall or a roof's plane, designed to triangulate the angles of it and thereby make rigid those angles, specifically that they may resist deflection by wind-pressure—the commonest natural hazard to buildings.

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After studying painting and drawing, silversmithing and cabinet-making, Cecil Hewett spent twenty years teaching these subjects and others in Essex schools. He is now employed as a specialist in timber-building and is also Consultant Advisor on Medieval Buildings to Essex County Council Planning Department. A contributor to numerous learned journals in Britain and the USA., Mr. Hewett is also the author of two other books on carpentry in which he pioneered the use of carpenters' jointing techniques as dating criteria.

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